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PROCEEDINGS

OF

THE ROYAL IRISH ACADEMY.

SCIENCE.

PAPERS READ BEFORE THE ACADEMY.

I.—On a new Step in the Proximate Analysis of Saccharine Matters. By James Apjohn, M. D., F. R. S.

[Read November 30, 1869.]

COMMERCIAL sugars and syrups (he stated) usually consist of cane sugar, intermixed with variable proportions of two other varieties of saccharine matters—namely, crystallized glucose, or grape sugar, and inverted sugar; but the value of a crude sugar or a syrup chiefly depends upon the amount of cane sugar present in it, and hence much interest has always attached to the methods adopted for determining its amount. The percentage of cane sugar in a syrup, containing no other active substance, admits, as is well known, of being determined by the rotation which it exerts upon the plane of polarization of a ray of plain polarized light; and though the two other sugars should be present, one of which (the grape sugar) rotates to the right, while the other rotates to the left, there are means of determining the rotation due to the cane sugar, from which its amount may be calculated. As respects, however, the inverted and grape sugars, the quantities of *these* present cannot be determined solely by optical means; and the principal object of his Paper, Dr. Apjohn observed, was to explain how the complete proximate analysis of a syrup including the three sugars could be made.

His method of accomplishing this object he then showed to consist in the performance of two optical experiments—one before, and the other after the inversion of the syrup; and a single chemical experiment, in which Barreswill's well-known solution of copper is employed.

These experiments conduct to the three following equations, which constitute a solution of the problem :—

$$
\begin{aligned}
&1^{\circ}. \quad x \times 0{\cdot}24 + y \times 0{\cdot}086 + z \times 0{\cdot}182 = \theta \\
&2^{\circ}. - x \times 0{\cdot}24 + y \times 0{\cdot}086 + z \times 0{\cdot}182 = \theta' \\
&3^{\circ}. \quad x \times 1{\cdot}16 + y \times 1{\cdot}1 + z = w.
\end{aligned}
$$

x, y, z are respectively the weights of the cane, the inverted, and the grape sugars in the syrup; θ, θ', the rotative powers of the syrups before and after inversion.

In equation 1°, the numerical coefficients of x, y, z, are the rotative powers of a unit weight of the respective sugars.

In equation 2°, 0·36 is the coefficient of inversion of cane sugar.

In equation 3°, w is the combined weight of the three sugars, each being estimated as grape sugar.

II.—On the Formation of Thenardite in Connexion with the Date of the Glacial Period, and the Temperature that prevailed during it, as deduced from the Influence of the Excentricity of the Earth's Orbit on the Length of Summer and Winter in Aphelion and Perihelion. By William K. Sullivan, Ph. D., Secretary to the Academy.

[Read December 13, 1869.]

It seems to be now generally admitted that at a time immediately anterior to the human period, if not actually within it, a low temperature prevailed over a large portion of the temperate regions of Europe and North America, and that the cold was accompanied by a considerable development of glaciers. There is, however, much difference of opinion as to the geographical range of the low temperature, and the degree of cold. Both have perhaps been exaggerated, and this exaggeration has greatly influenced the character of the hypotheses proposed to account for the Glacial Period. Sir Charles Lyell and many of his followers look upon changes in the relative amount of land and water, and their distribution on the surface of the globe, as the dominant cause of changes of temperature in geological time. But the difficulty of admitting that changes in the extent and distribution of land and water sufficient to account for phenomena usually attributed to the action of ice, or which are assumed to indicate a low temperature, could have occurred over so large an area in geological times so recent, has led geologists to seek a cause in astronomical changes, especially in the influence of the precession of the equinoxes and the revolution of the apsides on the seasons.

Although the actual amount of heat which falls upon the northern hemisphere in summer, whether the latter occurs in aphelion or perihelion, is equal to that which falls upon the southern hemisphere, M. Adhemar argues that the climatal effects are different, because the average temperature does not depend alone on the amount of heat re-

ceived, but also upon the amount retained. That is, although the actual amount of heat now received during 4296 hours of day in the southern hemisphere is as much as that received in the northern hemisphere during 4464 hours of day, yet, as the radiation during 4464 hours of night in the southern hemisphere exceeds that which takes place in 4296 hours of night in the northern, the mean temperature of the former hemisphere must necessarily be lower than that of the latter. Owing to the joint action of the precession of the equinoxes and the revolution of the apsides, the seasons make a complete revolution in 21,000 years, so that in each hemisphere summer occurs alternately in perihelion and aphelion, and each consequently endures in turn the longer winter in aphelion.

The effects of these astronomical changes, though not recognizable in the present condition of things, being completely masked by the far greater effects due to physico-geographical causes, increase with the excentricity of the earth's orbit, which is always altering, so that with a very high excentricity considerable changes in climate may result from purely astronomical causes. At present the excentricity is small; but there was a time when it was less, and periods when it was from three to four or five times greater. Thus the number of days by which winter occurring in aphelion exceeds summer in perihelion varied from 4·9 to as much as 36·4, or 28·3 days more than at present. Mr. Stone, acting upon a suggestion made to Mr. Airey, the Astronomer-Royal, by Sir Charles Lyell, calculated by Le Verrier's formula the excentricity of the earth's orbit at different periods. Mr. James Croll completed these calculations for the last 1,000,000 years. With the value for the excentricity thus obtained, and assuming the temperature of space to be −239° Fahr., the mean temperature of the hottest month in London to be 64° Fahr., and of the cold months 38° Fahr., Mr. James Carrick Moore calculated the number of days in which the winter occurring in aphelion should be longer than the summer in perihelion, and the mean temperatures of the coldest months during the former, and of the hottest during the latter, at the locality of London for a number of periods in the last 1,000,000 years.

Such calculations are necessarily only rough approximations ; and as they do not, and could never take into account the great disturbing influences of the relative positions of land and water, they merely indicate the probable extent to which these astronomical causes may influence climate, supposing the temperature of space assumed to be not very far from the truth. The table of results calculated for intervals of 50,000 years given by Sir Charles Lyell* are nevertheless of very great interest, and deserve the serious attention of geologists. Among other points of interest, they suggest a definite date for the Glacial Period, and give one of the elements upon which the temperatures which prevailed during that period depend. They even give, as I have stated, the approximative mean temperatures of the hottest and coldest months

* Principles, 10th Ed., vol. i., p. 293.

for those times in which the distribution of land and water did not materially differ from the present. At two periods within the last 1,000,000 years the calculated temperatures would be sufficient to account for the phenomena of the Glacial Period. The nearest of these occurred 200,000 to 210,000 years ago; and the more remote, 750,000 to 850,000 years ago—an interval even more temperate than the present intervening between the two latter periods, 800,000 years ago. The excentricity, 210,000 years ago, was 0·0575, or 3½ times the amount of the present; so that winter in aphelion would exceed summer in perihelion by 27·8 days. The mean temperatures of the hottest and coldest months, calculated for a place in the position of London, would, upon the hypothesis above stated, be 113° Fahr., and 0°·7 Fahr. The excentricity 750,000 years ago was the same as 210,000 years ago; then came a period, 800,000 years ago, at which the excentricity was only 0·0132, or less than at present, being now 0·0168. This excentricity gives 6·4 days more in winter in aphelion than in summer in perihelion, and mean temperatures for the hottest and coldest months at London of 82° and 22° Fahr.

One hundred thousand years previously, that is, 850,000 years ago, the excentricity amounted to 0·0747; this should have given a winter in aphelion 36·4 days longer than summer in perihelion, and a mean temperature for the hottest and coldest months at London of 126° Fahr. and -7° Fahr., a true glacial cold.

These extreme temperatures, produced in opposite phases of the revolution of the apsides, are necessarily accompanied by extreme winter and summer temperatures in the same year, at any given place. If the average temperature of the coldest winter months in London was so low as - 7° Fahr., the summer temperature must have been correspondingly high; because, as I have said before, the actual amount of heat falling upon the northern hemisphere during the shorter summer in perihelion must have been equal to that falling during the longer summer in aphelion. Professor Tyndall has well observed, that the aim of writers on the subject of the formation of glaciers is the attainment of cold, whereas heat as well as cold is required. The true conditions are, in fact, extreme temperatures combined with certain geographical conditions—namely, a suitable expanse of sea to act as an evaporating surface to produce vapour, and of high lands and mountains to act as condensers of the vapours. In Siberia and Central Asia excellent condensers are to be found; but there are no evaporating surfaces, for the vapours of the Indian Ocean are intercepted by the Himalaya. Hence no glaciers are found on the southern declivities of the Altaï and Sayan mountains. More vapour appears to come from the Northern Ocean than from the high central table land; for it is worthy of remark, that the only glaciers on the Sayan range are on the northern declivity, as, for instance, the curious glacier of the Mungau Xardik. The extreme temperatures which the revolutions of the seasons, under the influence of a high obliquity of the earth's orbit, should produce, appear then to suggest a possible cause of a

Glacial Period, such as that surmised to have existed in Middle and Western Europe at the commencement of the Human Epoch.

Without wishing, however, to attach undue importance to the astronomical causes just discussed, I desire to direct attention to another kind of evidence of the existence of extreme temperatures, rather than of great cold throughout the year in Europe, at a period probably coincident with the so-called Glacial Period. This evidence, though of special interest in connexion with the astronomical speculations just noticed, is independent of them, and is of equal value in connexion with any other hypotheses that may be proposed to explain the causes of the low temperature which undoubtedly did once prevail in temperate regions of Europe.

Our knowledge of crystallo-genesis, and of the conditions under which the chemical combinations forming rocks are produced, is as yet too limited to help us very much in the great geological problem—the determination of the temperature which prevailed under certain given circumstances, at any period of geological time. The present state of the question as to the genesis of the granitoid and other allied rocks, shows how much yet remains to be done before crystallo-genesis shall be in a position to supply us with information as to temperature, where organic life fails. Wherever crystallo-genesis does give us a full answer, the information is usually more definite and precise than even that afforded by life. Thus the existence of rhombic crystals of sulphur in a fissure or geode is a certain proof that the temperature at which the crystals were formed was below 100° Cent. Again, when brookite occurs in a rock, we may be sure that after the formation of that mineral, the rock had never become heated to a temperature even approaching dull redness. And again, the water of crystallization of gypsum is certain evidence that that mineral was formed at temperatures below 360° Cent. The evidence of the existence of extreme temperatures at a former geological time, to which I desire to draw attention, is of an analogous kind.

When disodic sulphate crystallizes at temperatures below 35° Cent., it takes up ten molecules of water, and forms glauber salt; above 35° it crystallizes as an anhydrous salt. Both salts occur in nature—the hydrated salt as sulphate of soda, or mirabilite; and the anhydrous salt, as thenardite. The hydrated salt must have been formed from cold solutions, or at least from solutions which were under 35° Cent. when the crystals were formed. Thenardite, on the other hand, must have been formed in solutions above 35° Cent. Until very recently thenardite was a rare mineral, having been noticed only in certain springs near Aranjuez, in Spain, where it was discovered in process of formation; in the salt-beds of Ocaña in the same district; and, lastly, in the salinas of Chili, accompanied by a mineral called glauberite, consisting of a combination of anhydrous calcic and sodic sulphates, or, in other words, thenardite and anhydrite. Within the last few years great deposits of thenardite and glauberite have been

discovered in the centre of Spain, and were described by Professor J. P. O'Reilly and myself, in a paper published in 1863.*

The beds of sulphates, which in some places are nearly sixty feet thick, form a line of escarpments along the left margin of the Vega, or alluvial plain of the river Jarama, below where it is joined by the Mazanares, and above where it falls itself into the Tagus. The beds of sulphates occupy apparently the hollow of an ancient lake, resting on the tertiary fresh-water limestone of the district. The river appears to have cut its channel along one side of the beds, and rapidly eroded the plain or Vega through them, leaving them only on the left side of the river valley. The deposits consist of thin beds of thenardite mixed with glauberite, and more or less discoloured with a fine greenish mud, and separated by bands of a similar material containing lumps of fibrous gypsum, and fragments of the underlying limestone.

Some specimens of the thenardite consist of colourless compact masses of crystals of the anhydrous sulphate. These crystals are not pseudomorphs of the hydrated sulphates produced by the drying of masses of glauber salt, but must have formed directly as anhydrous sulphate from solution. The association of glauberite also proves that the sulphates were directly formed in the anhydrous state.

On the beds rests a deposit of gravel, containing pebbles of the syenite and other rock of the Guaderama range, whence the Jarama issues. The deposits of sulphates we believe to be contemporaneous with the glacial drift of Ireland.

These beds afford absolute physical evidence that during their formation the temperature of the air during part of the year was sufficiently high to raise a solution of sulphate of soda to a temperature exceeding 35° Cent. In order that saline solutions in lakes or shallow ponds should reach a temperature of 35° to 40° Cent., the temperature of the air should be at least 50° Cent. Temperatures even higher than this have been noted in Africa. Sir John Herschel found that the temperature of the soil in South Africa attained the great heat of 70°·5 Cent., or 159° Fahr. On the shores of the salt lake of Bahr Assal, which probably at one time formed part of the Bay of Tajura, near the mouth of the Red Sea, Major Harris observed a temperature, under the shade of umbrellas and cloaks, in the beginning of June, of 52°·24 Cent., or 126° Fahr., and conjectures that towards the end of July it might have reached 60° Cent., or 140° Fahr. As the temperature of this place, called by the Arabs the Gates of Hell, was nearly as high at night as in the day, there can be no doubt that thenardite and glauberite would be formed, if, instead of common salt, the lake contained disodic sulphate. Indeed, we may be sure that among the salts which are now forming in the half-dried lake, are some crystals of thenardite.

Having shown that the Spanish beds of thenardite require a high

* Atlantis, vol. iv., p. 288; and Notes on the Geology and Mineralogy of the Spanish Provinces of Santander and Madrid, p. 139.

summer temperature, I now come to the evidence of a low winter temperature. Disodic sulphate or sulphate of soda is produced naturally by double decomposition of certain salts in solution at a high temperature, or at very low temperatures. In the memoir of Mr. O'Reilly and myself, already referred to, we have discussed very fully the formation of sulphate of soda in nature, and shown, as I believe, that the sulphate of soda of the beds of the Jarama could only have been formed by the natural decomposition of sulphate of magnesia and common salt in solution, or of sulphate of lime and common salt under the same circumstances. The presence of abundance of gypsum, and of the combination of the sulphates of lime and soda in glauberite, speaks strongly in favour of gypsum being the source, in part at least, of the sulphate of soda. The sulphate of soda beds and lakes of the steppes of the Aral Sea, described by Herr Nöschel, which are clearly the result of saline decompositions at low temperatures, afford a complete key to the formation of the sulphate of soda of the Jarama. In fact, the circumstances are so similar, that the only thing wanting in the Aral steppes to produce beds of thenardite, similar to those of Spain, is a temperature sufficiently high to raise the solution of sulphate of soda in the lakes and ponds above 35° Cent. Such a temperature would be produced, if the excentricity of the earth's orbit were increased to what it was 200,000 or 210,000 years ago.

Even though further investigations should establish that the deposits of the valley of the Jarama are older than the glacial drift, they will still be evidence of the prevalence of extreme temperatures, such as characterized the period of the glacial drift at another and an earlier period. Indeed, if, as some think, the glacial drift should be assigned to the last astronomical period of great excentricity, 200,000 years ago, and that the Jarama beds are older than the sands and clays near Madrid, in which the bones of an elephant were found, and which are probably contemporaneous with the drift, the thenardite of the Jarama might with great probability be assigned to the earlier cold period, 750,000 years ago. If this were so, the interest of these deposits would be still greater, because for the first time we should have an absolute standard for measuring geological time. In any case the Jarama beds are deserving of the attention of geologists in connexion with the question of the climate of Europe at the beginning of the present epoch.

III.—ON THE ILLUMINATION OF MICROSCOPIC OBJECTS. By JOHN BARKER, M. D. (Plates I., II., III.)

[Read January 10, 1870.]

THE Academy are, doubtless, aware that one of the most important improvements of late years in object glasses of high powers has been the immersion of the object glass of a particular construction into a

film of water, to be placed on the covering glass of the object; and it is found that definition, working distance, light, and magnifying power are much improved thereby; these object glasses are called immersion lenses, or hydro-objectives. Now, it is the purpose of this communication to introduce the same principle of immersion to be applied to the illumination of microscopic objects, whereby corresponding advantages will, I believe, be found to accrue.

Having thus stated the object of this Paper, it would seem that little further need be said, the details of the application of the principle of immersion illumination, and the advantages arising, being almost self-evident, I think the Academy at large will take sufficient interest in the enumeration of these details and advantages to permit me to occupy their time a little longer.

If we regard the best way of viewing objects by unassisted vision, we shall easily arrive at the conclusion that an object is best viewed where it is illuminated by diffused light—that is, where the light reaches the object from all azimuths and altitudes; does not impinge on the retina, except from the object itself; and where the light is sufficient, and not too bright. Parallel rays of light give rise to disturbing shadows, which may lead to erroneous conceptions of the true character of the object; and light concentrated from one quarter or side introduces errors of the same character, although not to the same extent. It was a belief that the same manner of illumination which is found to be best adapted to unassisted vision would also be found to be that best suited for microscopic objects that led me to examine the subject more carefully.

Ordinarily, when we look into a microscope, we feel disposed to shrink from the sudden glare of light which floods the field, contracts the pupil of the eye, and in time injures the retina, this glare prevents us at first from seeing anything whatever; presently, we begin to perceive a something, transparent in parts—in fact, the object under the microscope is rendered visible by the relative opacity and transparency of its parts, the shadows which the more opaque parts cast on others and on the eye, and the caustics of light which the highly refracting and reflecting portions of the object throw on those of different density. Now, all these effects are injurious to the recognition of the true aspect of the surface and structure of an object, and must lead to erroneous impressions—in proof of this I may refer to the many, and various, and different interpretations of minute forms put forward by microscopists, arising more from defective modes of illumination than from errors on the part of the observers.

Mr. Grubb, and the late Mr. Bergin, long ago perceived the value of properly regulated illumination; and Mr. Grubb's stand is considered to be one of the most perfect, where side light is admitted; but if shadows be considered to be injurious to correct vision, much time and shifting of the object and light will be required to obtain a true interpretation of what is seen. For lined objects, the microscope of Mr. Grubb leaves little to be desired in an instrument, and London and

American microscopists are only very lately extending the principles of his instrument. However, I believe that those means of illumination which are placed in the axis of the microscopic tube will ultimately be found to be the best, as they do not throw shadows on any part of the object.

I have as yet practically examined only one form of this axial illumination, in connexion with the principle of immersion, and have made use of the glass paraboloid as the one best suited to the experiment. Wenham, to whom we owe so much in microscopic science, was the first to introduce the parabolic reflector, which afterwards assumed the shape of a truncated paraboloid of glass, to be placed beneath the stage, whereby parallel rays of light are concentrated from all azimuths to a focus in which the object is placed; the central rays are stopped off, so as not to allow useless light to flood the field of view; and a cup-shaped cavity is made above, to allow the light to leave the paraboloid without deviation (*see* Plate I., fig. 2). It is to this apparatus that I have applied the immersion plan, and it seems to me to have removed almost all its imperfections, and to place the microscopic object under circumstances similar to those under which objects submitted to unassisted vision are best seen. In the first place, in the old construction, there is great loss of light (*see* Plate I., fig. 1), from the way in which the rays of light leave the paraboloid and strike the under surface of the slide; and the most valuable rays (those most oblique) are lost in much greater proportion than others. Secondly, the light undergoes dispersion, if the object be in balsam or fluid—indeed, in any case—and the oblique rays cease to be achromatic. To obviate some of these imperfections, Wenham has lately suggested the use of a small, deep plano-convex lens, to be cemented to the under surface of the slide (*see* Plate II., fig. 1) on which the object to be examined is placed; but this it is practically impossible to use in investigations of the ordinary kinds.

By making, in the construction I would suggest, the top of the paraboloid flat (*see* Plate I., fig. 3), and introducing a film of water, or, better, a fluid of a deflective power as nearly as possible equal to that of glass, between it and the under surface of the slide, nearly all these imperfections will vanish; for optical contact will then be made between the paraboloid and slide; and also the film of water will act as a water joint, and allow free action to the stage movements, so that any part of the slide can be easily examined. The oblique rays are thus best economized; little dispersion takes place, if the object be in liquid or balsam, and there is sufficient brightness for all powers. Another advantage arises unexpectedly; for if the focus of the paraboloid be made a little higher, or if a slide of extra thinness be used, the oblique rays will undergo total reflection from the upper surface of the covering glass, and be sent down on the object so as to illuminate it by reflected light, a desideratum not hitherto accomplished in a satisfactory manner (*see* Plate III., fig. 1); the light also does not strike the object glass, which is a great source of glare in many of the other forms of oblique illumination.

I have placed on the table this illuminator, made by Mr Yeates,

adapted to a $\frac{2}{3}$rds object glass, with the binocular tube, and I think the results there exhibited (which the Members can view after the meeting) will be found to be satisfactory.

The size and curvature of the paraboloid is easily made out, if the focus be chosen $\frac{1}{12}$th of an inch above the upper surface, the equation of a perpendicular section $y^2 = ax$ will become $y^2 = a\left(\frac{a}{4} + \frac{1}{12}\right)$; and solving the equation for a, we shall have $a = -\frac{1}{6} \pm \sqrt{4y^2 + \frac{1}{36}}$; and if the upper surface of the paraboloid be made $\frac{3}{4}$ths of an inch in diameter (a size most convenient in practice), a becomes = to $\frac{3}{4}$, and the equation $y^2 = \frac{3}{5}x$ is that of the paraboloid form. Should the focus be taken at a distance of $\frac{1}{10}$th of an inch above the truncated paraboloid, and its upper surface be one inch in diameter, then the equation becomes $y^2 = \frac{3}{7}x$ *quam proxime*:* this latter form will admit of a hollow cone of light of 120° – 185°, and will almost give a dark ground illumination for an 8th immersion object glass. I have also on the table another microscope, in which, by this illuminator, the Pleurosygma formosa is well seen. A useful addition to this instrument will be found in cementing an Abraham's prism to the bottom of the paraboloid, adapted to a focus of about 14 inches, so that the rays from a lamp, at that distance, will be easily concentrated on the object (*see* Plate II., fig. 2).

Should direct light be required for any mode of investigation, even with some of the highest powers, another form of microscope could be made, by turning the paraboloid upside down, and placing the object glass in its centre; and by using a perforated reflector, placed in the body of the microscope, and the immersion principle, a new instrument can be produced, and which, I think, may be useful for some kinds of objects (*see* Plate III., fig. 2).

The same principle of immersion is applicable to all kinds of axial condensors, and I am sure, when they come to be tried, will give results equally satisfactory, and possess advantages similar to those I have observed in the form of dark ground illumination, which I have had the honour to bring before you.

Allow me briefly to recapitulate the advantages which I claim for this mode of illumination:—

1. The object under the microscope will be seen by light reflected from its surface and from its interior (if transparent);
2. It will allow no disturbing light to impinge on the retina;
3. It will get rid of almost all shadows;

(*) The above calculations have been simplified by not allowing for the deviation caused by the intermediate fluid, and also by the medium in which the object is placed. Should water be used (as required in many cases) some modification of the above will be necessary, and the araboloid should be formed accordingly; $y^2 = ax$ will then assume the form $y^2 = \frac{1}{10}$ or $y^2 = \frac{1}{8}x$, and the focus will be $\frac{1}{10}$th or $\frac{1}{8}$th of an inch above the upper surface of the paraboloid; in the latter case, a rather thick slide will be required.

4. It will economize the oblique rays of light;
5. It will be purely achromatic;
6. It will light up the interior of a partially transparent object;
7. It will improve definition;
8. It is easy of application;
9. It will not be an expensive addition to the microscope.

IV.—ON THE SMALL OSCILLATIONS OF A RIGID BODY ABOUT A FIXED POINT UNDER THE ACTION OF ANY FORCES, AND, MORE PARTICULARLY, WHEN GRAVITY IS THE ONLY FORCE ACTING. By ROBERT STAWELL BALL, A. M., M. R. I. A., Professor of Applied Mathematics and Mechanism, Royal College of Science for Ireland. [Abstract.]

[Read January 24, 1870.]

A RIGID body rotating about a fixed point may be moved from one position to any other position, by rotation around an axis termed the 'axis of displacement' through an angle termed the 'angle of displacement.' This is a well-known theorem.

The equations of motion, being linear, depend, as usual, upon a cubic equation. The roots of this cubic give criteria as to the nature of the equilibrium.

A 'normal axis' is defined to be "a direction passing through the fixed point, about which the body will oscillate as about a fixed axis, when the initial 'axis of displacement' and instantaneous axis coincide with this direction."

When the roots of the cubic are all real, positive, and unequal, there are three 'normal axes,' and small oscillations of the body are compounded of vibrations around these three axes. Hence we infer the general theorem.

'If a rigid body, rotating around a fixed point, perform small oscillations about a position of stable equilibrium under the action of any forces, its motion is produced by the composition of vibrations around three fixed axes passing through the point, and each of the vibrations about the fixed axes is performed according to the same law as the vibration of the common pendulum.'

If only one of the roots of the cubic be a real positive quantity, and if the initial 'axis of displacement' and instantaneous axis coincide with the 'normal axis' corresponding to this root, equilibrium is stable relative to such a displacement, but for any other initial 'axis of displacement' or instantaneous axis the equilibrium is unstable.

If two of the roots of the cubic be real, positive, unequal quantities, while the third is negative, and the 'normal axes' corresponding to the two positive roots be constructed, then if the initial 'axis of displacement' and instantaneous axis lie in the plane containing the normal axes, the equilibrium is stable, while if either of these axes be not contained within this plane the equilibrium is unstable.

If the forces which act on the body have a potential, a simple geometrical construction determines the 'normal axes.'

The quantity of energy necessary to give the body a certain displacement can be expressed in terms of the 'angle of displacement,' and the direction cosines of the 'axis of displacement.' If along every radius passing through the fixed point a length be measured from the fixed point proportional to the displacement which a given quantity of energy could produce about that axis, the locus of the extremities of these radii vectores is called the 'ellipsoid of equal energy.'

The greatest and least axes of the 'ellipsoid of equal energy' are the directions about which the same quantity of energy would produce the greatest and least effects.

For a displacement from the position of equilibrium around any radius vector of this ellipsoid, the moment of the forces acts in the plane conjugate to that radius vector.

The 'normal axes' are the three common conjugate diameters of the momental ellipsoid, and the 'ellipsoid of equal energy.'

The length of the simple pendulum isochronous with the vibration about each axis is proportional to the square of the ratio of the corresponding diameter in the 'ellipsoid of equal energy' to that of the momental ellipsoid.

When the times of vibration about two of the 'normal axes' are identical, the construction becomes indeterminate for these axes, and every direction in the plane conjugate to the third normal axis is a normal axis.

When the times of vibration about three axes not in the same plane are equal, every direction passing through the fixed point is a 'normal axis,' and the motion of the body is isochronous, whatever be the initial circumstances. A body thus related to the forces which act on it may be called an 'universal pendulum.'

In the 'universal pendulum,' the plane which contains the initial instantaneous axis and 'axis of displacement' continues to contain them throughout the motion.

Every point of the 'universal pendulum' describes an infinitely small ellipse.

The small oscillations of a rigid body suspended from a fixed point different from its centre of gravity, and acted upon by gravity, but by no other force, is discussed: this is the question of the conical pendulum in its most general form.

The fixed point being joined to the centre of gravity, a plane is to be drawn in the momental ellipsoid conjugate to this line. This plane is called the 'conjugate plane.'

The body may be displaced from a position of equilibrium to any given adjacent position by rotation around a certain axis through a small angle, this axis lying in the 'conjugate plane.'

For small oscillations it is necessary that the instantaneous axis should always lie in the 'conjugate plane.'

In the present case there are two 'normal axes,' and all vibrations of the body are compounded of those about the 'normal axes.'

The position of the 'normal axes' is determined by a quadratic equation, whose roots are the squares of the semi-axes of a certain section of the momental ellipsoid.

An ellipsoid is to be drawn whose axes are in the same direction as the axes of the momental ellipsoid, and proportional to their squares.

The 'normal axes' are the common conjugate diameters of the sections in which this ellipsoid and the momental ellipsoid are cut by the 'conjugate plane.'

Hence the 'normal axes' are parallel to the sides of the parallelogram formed by the four points of intersection of the ellipses.

In general, the 'normal axes' are not at right angles, but the vertical planes drawn through the 'normal axes' are always at right angles.

If the centre of gravity lie in one of the principal planes, the corresponding principal axis is one of the 'normal axes', and the other axis is perpendicular to it.

If the moments of inertia be equal about two of the principal axes, one of the 'normal axes' is perpendicular to the plane containing the centre of gravity and the third principal axis, and the other is in that plane.

If the centre of gravity lie on either of a certain pair of lines, passing through the point of suspension, the times of vibration about the 'normal axes' are equal, and the body vibrates isochronously under all initial circumstances.

The 'ellipsoid of equal energy' becomes a cylinder in this case, and the common conjugate diameters of the sections of the cylinder and the momental ellipsoid by the 'conjugate plane' are the 'normal axes.'

The identity of the two constructions is easily seen.

The motion of the instantaneous axes in the 'conjugate plane' is one of oscillation.

The motion of the centre of gravity is compounded of two simple harmonic vibrations at right angles to each other.

Some apparently exceptional cases are discussed.

V.—MICRO-ATMOSPHERIC RESEARCHES. By GEORGE SIGERSON, M. D., Ch. M., F. L. S. (Plates IV., V., VI., & VII.)

[Read January 24, 1870.]

ABOUT a year ago I commenced a series of Microscopic Researches on the Atmosphere, the results of which are represented by the drawings. Until I had completed them, I confess that the labours of others in a similar direction had escaped my notice. These researches have obtained thereby the character of an independent investigation. Having been commenced with no foregone conclusion, nor any reference to

the Pasteur-Pouchet controversy about spontaneous generation, a comparison of these results with what those inquirers have obtained can hardly fail to be of some interest.

Former observers, I find, have recognised in the dust subsiding from the air spores of fungi, lichens, algæ, and mosses, the detritus of the soil, fine fragments of vegetable and animal fabrics accidentally diffused; the dried, but vital, bodies of infusoria; and the eggs of the lower members of the animal kingdom. Besides these, in cities, they have observed fragments of the products of manufactures, with the spores of fungi, mixed with particles of carbon or soot, the ova of lower animals being few.

M. Pouchet declares that the air everywhere is naturally fecund, but that usually it nowhere contains ova or spores. However, he qualifies this by observing, that the atmosphere may be the vehicle of such objects; yet he adds—"I have experimented on the air taken from open sea, between Corsica and Sicily, and on other specimens gathered, in perfectly calm weather, in the midst of the Ionian Sea; I have also taken air of the summit of Etna, and from the depths of the recesses of the caverns of Caumont, near Rouen; and none of my experiments [on the fecundity of the air] have been stricken with sterility. Nevertheless, in analysing this air by the aëroscope or otherwise, no egg of infusoria or other seed was found in it."*

And again, he says, "There are so few seeds or germs in the air, that even in places where plenty should be found they are only met with exceptionally. M. Musset, who has been long engaged in researches on fungi, whose laboratory is quite filled with them, informed me recently that he never yet has been able to meet with spores there."

Whilst, by employing three kinds of tests, M. Pouchet found it difficult to discover an ovum or a spore in a hundred cubic yards of air, he asserts that with a decimetre of the same air he could at will produce thousands of animalculæ and plants. In the atmosphere of French towns he observed particles of starch in three states—first, in a normal condition; secondly, panified; and, thirdly, having a blue colour. He asks whether the iodine recognised in the atmosphere by M. Chatin may not have thus coloured it? Starch granules he has found frequently. Soot and fragments of clothing are also common. As by a chance there occur in the atmosphere wandering seeds or germs, the corpses of animalculæ, and even some live individuals, he considers it but natural that here and there eggs and spores may be seen. But their number is so scanty that they must be taken as absolutely null, in the controversy and experiments having reference to spontaneous generation. Having been contemporaneously with, but independently of, Messrs. Joly and Ch. Musset, the first to examine snow for the purposes of atmospheric micrography, he found it enormously charged with detritus of various kinds, with soot, with normal

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* "Nouvelles Experiences sur la Generation Spontanée et la Resistance vitale, par F. A Pouchet." Paris, 1864.

and blueish starch, and with a considerable number of Protococcus nivalis, a beautifully green plant.

In the lungs and air-vessels of city birds he found starch granules, and soot, and fragments of clothing; in country animals, only *debris* of plants and pollen. In the lungs of a man and a woman who had died in an hospital, he came upon a notable quantity of starch granules, both normal and panified; fragments of flint and glass, of a red-coloured wood, of clothing; and, lastly, the living larva of one of the arachnida.

"In all our experiments," he adds, "which, without exaggeration, may be reckoned by hundreds, we have never encountered either a solitary spore, an egg of lower animal, nor an encysted animalcule."

Hermann Hoffman, on gooseberries, found some traces resembling the yeast and spores of Cladosporium and of Stemphylium. On the other hand, Ehrenberg, Burdach, Baer, Hensche, Wagner, and Leuckart failed, like Pouchet, to find either ovum or spore in the atmosphere. Joly, Musset, and Baudrimont declare they are extremely scanty. "Until now," wrote the latter from Bourdeaux, "I have not found in the air we breathe those monsters and fantastic creatures wherewith the imagination of man has peopled it." Schaaffhausen, Professor at Bonn, remarked that "one would seek in vain for ova subsiding from the atmosphere in open vessels, used for experiments." With reference to spontaneous generation, Bechi, in studying the dew of the Maremmas of Tuscany, found no trace of the reproductive bodies of animals or plants. M. Pasteur, on the contrary, with some adherents, believes that the atmosphere abounds in germs, though some tracts of it may be barren.

One practical result of this discussion was, that Dr. Eiselt, of Prague, investigated the atmosphere of his hospital, and found particles of contagious ophthalmia, then an epidemic.

With the discussion of the question of spontaneous generation I have here nothing to do. The contents of the atmosphere were chiefly interesting to me, inasmuch as they affected health.

On the accompanying Plates are represented the results of my investigations of—1st. "The Sea Breeze" (Plate IV.); 2nd. "Country Air" (Plate V.); 3rd. "City Air" (Plates VI. and VII.).

The Sea Breeze.—Glass, on being exposed to the influence of the sea air, was found to become quickly tarnished. On making a microscopical examination of this, the cause was readily found. Crystals innumerable were seen deposited upon it, most of which, on account of their shape and the circumstances, were recognised at once as crystals of chloride of sodium, or common salt. Some were deposited in minute drops of water, where they increased in number by the formation of new crystals; some were deposited already crystallized and in a dry condition, like hailstones. The moisture is taken up from the waves by the wind in its course over them; and, whilst so suspended in the air, favoured by its agitation, the crystals are frequently formed.

Having used several object-glasses, with intent to secure accuracy,

the objects were finally drawn, as magnified by the $\frac{1}{8}$th object-glass. So enlarged, they are represented on the Plate. Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, are drawings of characteristic groups, where the rounded or irregular globules show the moisture, whilst the rectangular forms within so many of them are those of the crystals. It was a most beautiful sight to see them in the process of formation, and to observe those formed under their transparent veil of water, that liquidly rounded over their upper lines and angles in a manner too delicate for the pencil to pourtray on a scale so minute. In some globules, as fig. 6, one crystal was set upon another; in others, as figs. 4 and 5, there were crowds, more or less irregularly heaped. Groups of crystals, apparently deposited from the breeze, already formed and in a dry state, are shown in figs. 7 and 10. Again, at fig. 12, they are found in contiguity with minute drops containing crystals. The dry ones had either come from a greater distance, or been longer in the air. Right rhombic crystals of sulphate of magnesia are represented in fig. 9; of these, comparatively few were found. Finally, though the object represented at fig. 13, as well as the oblong outlined object at fig. 12, were found with the sea breeze, they were not belonging to it. They came from human beings on board a vessel in which some of the experiments were made.

From a medical point of view, the knowledge of the existence of such crystals may be of importance. A shower of such minute salt hail rattling down through the lung pipes or into the eyes has its effect. Thus they may help to irritate weak eyes; and I have seen chemosis, a sort of dropsical effusion of the conjunctiva, arise in delicate children, on exposure to the sea air. On the other hand, salt, being a gentle stimulant, as well as a rubefacient, may, in indolent or chronic cases, be of use.

The effect, in lung diseases, cannot be of little importance. The breathing of air containing crystals of salt is likely to irritate and injure in at least some stages of consumption, whilst in other stages it is possible that it may be of advantage. In acute inflammatory affections it is likely to prove injurious; in slow chronic cases it may assist a cure.

It is probable that the quantity of salt in the sea air is far from constant; the results of an investigation into the sea breeze of the west and north coasts of Ireland is what I have here depicted.

These observations, I believe, will help to account for what is recorded as "the first of the wonders of Erinn" (according to the "Book of Glendalough"), mentioned in the Appendix to the Irish version of Nennius. Here is the statement:—"Innis Gluair in Irrus Domnann: this is its property, that the corpses that are carried into it do not rot at all; neither does the meat unsalted rot in it."

The fact of a great quantity of salt being borne on the Atlantic breeze affords, in my opinion, a reasonable explanation of this wonder. The second "wonder of Erinn" was stated to be the petrifactive power of Lough Neagh; modern investigations have corroborated the fact, and revealed the cause.

Country Air (Plate V.).—In this Plate are represented specimens of the objects captured during an examination of the air of the country. With the exception of the acarus shown in fig. 22, they are magnified with $\frac{1}{8}$th object-glass.

Fig. 1. The row of objects here depicted are droplets of dew, some of them being reduced in size for convenience' sake, whilst their contents remain magnified. It is seen that, although the dew has often been made the type of purity, it is, in reality, much adulterated with inchoate greenish matter (probably vegetable), with inchoate brown and dark matter (probably dust and soot), whilst there are some granules and minute batons whose origin it was impossible to tell. The dew, like the rain, washes the air. In one drop of dew collected off a leaf, where it could not have lain more than a couple of hours, a very lively monad was found disporting itself.

Fig. 2 represents a group of globules or germs, whose origin I cannot tell.

Figs. 3 and 8 are portraits of pollen-grains, four grains being occasionally grouped together. Fig. 5 is a grain of daisy-pollen. In 4, two germinating grains, with pollinic tubes prolonged, form a curious group. The pollinic tubes must have grown without penetrating the stigma; for, after having been once anchored, they would not be found uninjured in the air. They resemble germinating spores of *Blasia pusilla*. Fig. 7 is an undetermined object.

In fig. 6, the egg of an animalcule of some kind is shown.

Fungi found in the air form the assemblage of objects, ranging from figures 9 to 13, inclusive. Fig. 9 is seemingly a kind of mucor or mould, under which head we may class fig. 11.

Fig. 10 gives the filamentous fragment with spores, detached from the interior of a Lycoperdon, or puff-ball, knocked about and broken by the feet of cattle in the meadows.

Fig. 12 represents some objects which were captured whilst crossing a rural road. Evidently they were fungi; but to what to attribute them, or how to call them, embarrassed me at first. However, some time after sketching them, I made an examination of the atmosphere over a potato field, in which the potato disease had declared itself in the blackened leaves and halms, with a view to ascertain whether any specimens of the *Botrytis infestans* would be found in it. A breeze was blowing over the field, and shaking the tops. The result of my research was, that I not only discovered them (they are represented under Fig. 13), but was enabled immediately to identify the objects represented by Fig. 12, as being the same. They, indeed, appear to have been stragglers from this very field, and were wafted away to spread the disease to other fields, if we are to agree with the view that the potato murrain is due to this fungus. As it has been advanced by that distinguished cryptogamic botanist, the Rev. Mr. Berkeley, there is every probability of its accuracy. Taking this theory in connexion with the fact of the stragglers above-mentioned, which I found making their way from a centre of infection, the only

efficient way of eradicating the potato disease would seem to be one identical with that adopted for putting an end to the "rinderpest" in cattle, and which has received the name of the "stamping-out process." On inquiry, a cultivator informed me that it was believed that some slight advantage had been gained by burying the potato plants first infected. But, whilst this is encouraging, it is now plain that, for any "stamping-out process" to have a reasonable chance of success, it should be conducted carefully and generally. Unless the utmost care be used, the uprooting of a plant to bury it will shake off innumerable spores, to be blown away as contagion; and such care would not be thought of until it was taught that the disease was contagious, and that the contagion consisted of this minute fungus. Again, the anxious labour of one cultivator would be quite wasted, unless the rule were general; for his carefully manipulated field might receive a new shower of spores, with any turn of the wind, from fields which had been neglected.

If, therefore, it be desired to make a real attempt to extirpate a pest, which has caused, and may again cause, excessive misery and immense loss, the same earnest system of compensation, penalties, and scientific inspection should be adopted to eradicate the potato disease, as was employed successfully to annihilate the rinderpest.

Figs. 14, 15, and 16, are representations of crystals. Some of them represent raphides, and probably are the raphides of cells liberated from bruised, broken, or half-masticated plants. Others, such as fig. 16, appear to be crystals of hippuric acid, caught up by the winds from places which had received the excretions of herbivores.

Fig. 17 is the pectinate antenna of one of the Lanpyridæ.

Fig. 18 is a moth-scale of a remarkably beautiful form. Both scale and antenna were possibly lost in some struggle between their possessors and a piratical wasp in the air.

Figs. 19 and 20 show a number of objects, more or less contorted, chiefly remarkable for having a great number of hair-like processes. It was impossible to tell, with certainty, from what source they were derived. One resembled the spermatozoid of a fern, but the remainder appeared to be fragments of exuviæ of minute animals. The hair-like processes, like cilia, were found fine and semi-transparent.

Fig. 21, apparently a larva, on being measured with the micrometer, was found to be $\frac{1}{300}$th of an inch in length.

Fig. 22 is an acarus, magnified with 1 inch object-glass. This member of the Arachnida class was found in the air over heathery hills, at breathing level. It will be recollected that Pouchet found an arachnide-larva in one of the air-passages of the human lungs.

Considered from a medical point of view, I may remark that, whilst some of these objects might affect the lungs injuriously by mechanical occlusion, obstruction, or irritation of the finer air-pipes, some might influence them in another way. On the one hand, the dust, pollen, crystals, moth-scales, antenna, and the like, might—if they were not, as fortunately they are, few in number—tend to produce embolic phthisis.

The acarus sucked into the air-passage would probably do no more than plug it up, whilst causing by the action of its claws a certain additional amount of irritation.

On the other hand, knowing, as we do, of the growth of fungi in the mouth and fauces, as well as upon the skin, it is to be feared that their being taken into the air-vessels of the lungs would not deprive them of vitality. Their growth there should cause as much disturbance as in the mouth; but, on the other hand, they are less apt to send their mycelium into the lung, on account of the presence of ciliated epithelium. In cases where they have proved inoffensive, this has kept them off; then wrapt in mucus, they are coughed out. But there is no proof that they must be always inoffensive, though their agency has been as yet ignored. By spores in the air certain skin diseases may be propagated; whilst the presence of an acarus in the atmosphere shows how another member of the Arachnida class, *Sarcoptes scabiei*, may be carried about to propagate the itch, which in northern parts of the country used to be a not unfrequent burrowing visitant on the exposed hands. Perhaps this disorder is more usually spread by the egg. Now, the acarus described, if it entered the lungs, might simply cause mechanical occlusion, with some irritation superadded by the action of its claws. Dead, its decaying body might cause injury. But it is possible that it might live to produce its germs; the larvæ might survive long enough to cause much irritation. If a *Sarcoptes* were in-drawn, it would probably attempt to burrow immediately, as it does on the skin. Although some affections of the human lungs may probably be thus caused, it is obvious that the lower animals are far more likely to draw into their lungs these or similar injurious objects. The germs of parasites that will make their way into the system may thus obtain an entrance.

City Air.—Two Plates have been devoted to the objects discovered in the atmosphere of cities and crowds. One, with dark background, is an accurate transcript of four photomicrograms, which were selected from amongst several which I had taken when intending to use photography. It was abandoned for the pencil, as this was found more convenient, and apter to bring out more accurately the minuter objects and their internal anatomy.

Ordinary dust, being chaotic, was disregarded in making the drawings. Generally speaking, it is formed by the wearing away of the earth, and all things that on it are. In composition it varies with the locality. In the country the wind sweeps the roads and fields, and forms its dust of powdered clay and stone, some fine spicula of quartz, triturated fragments of excrementitious matter, rare and minute particles of the hair and wool of animals worn off. In towns, dust similarly is found, but particles of soot are frequent. Pouchet has found them in the lungs of city birds, together with starch granules, which I have never encountered. In manufacturing towns, like Belfast, a fine soot-dust falls plentifully. In the factory districts of England it falls in unwelcome abundance. The amount of carbon thus sent into the air

and breathed by the lungs may help to account for the pallid features, the carbonaceous countenances, so to speak, of the inhabitants of towns. The inhabitants of the country, or of small non-manufacturing towns, are more frequently seen with ruddy cheeks. Besides this, there was the dust arising from the wearing away of clothes and cloths of all kinds; of vegetable and animal hairs, and products ground off fine by every movement; of carpets, of furniture, and in libraries of books. Currents of air on walls and ceiling disintegrate and deprive them of particles; and into the dust of rooms we carry, on clothes and boots, some of the dust from out of doors, whilst an open window may let in a large quantity.

The characteristic special dust is what has been represented. In cities and crowds the motes are found to be frequently moist. Let us take first the photomicogram (Plate VI.).

Figures 2, 3, and 4 show the objects which were received on glass, at breathing level, on traversing streets and cattle shows. The plan adopted was simple—to don a pair of spectacles; and by this means motes were readily received from the atmosphere, in the most frequented places, without attracting undesirable notice. The vertical position of the glasses appears to count for little, as even a tolerable amount of dry dust adheres. When it was wished to search for what might have escaped the dry glass, a little glycerine was brushed over a portion of the glass, so as not to obscure the sight.

The dumb-bell shapes that appear in figs. 2, 3, and 4, are frequently found. A globule of mucus sent rapidly forth into the air, gyrating, tends to draw asunder, and to divide in twain. Before this is accomplished, the two separating globules are retained by a narrow isthmus that gradually becomes less, till it breaks. Numerous cavities, where air-bubbles existed, are seen in the dumb-bell mucus of fig. 2. In fig. 1 the rounder extremity of this dumb-bell is shown more largely magnified. Arborescent formations may be remarked, commencing here to display themselves; but they will be shown more perfectly developed upon another Plate.

The presence of numbers of minute objects in the air, very plainly shown in these figures, must not, however, mislead the observer to imagine that the atmosphere contains them in an equal space so abundantly. The quality, rather than the quantity of the motes in the air, is the subject of investigation.

It is to be remarked that some of the objects in fig. 3 might suggest to a casual investigator the idea that he had before him corpses of animalcules, and this would be an error.

City Air (Plate VII).—It is necessary to state, at the outset, that all the objects depicted here are not as when first deposited. For instance, if we look at figs. 1 and 7, we see that they are adorned with beautiful branchy formations in their interiors. These were not detected without some study. When first deposited upon the glass, these objects were but homogeneous mucus: if left too long, the exquisite shapes may not be detected at all, as after they are formed they have no

longer the same adhesive power, and may be blown or shaken off. When they have lain on the glass for a little time, the homogeneous mucus will, in certain cases, commence to resolve itself into the arborescent forms, until we have, as in fig. 1, the appearance of a number of fern leaves. In other cases, as in figs. 2 and 3, the formation may not become so distinctly dendritic; in others, as in portions of fig. 4, in 5, and in 6, this arborescence may not at all occur. They might be divided into three classes:

In the first class, as shown in figs. 1, 2, and 7, the mucus crystallizes out more or less completely into beautiful arborescent forms. To the presence of muriate of ammonia this is due; it is known to exist in some of the animal secretions, and its crystallization forms are characteristic.

These dumb bell forms may have emanated from the lower animals or from man. That represented in fig. 2 of the photomicrographic Plate was caught whilst passing through a cattle show, and, doubtless, was emitted by some lowing ox.

On the other hand, that shown in fig. 7 undoubtedly came from man, as it was captured at a public assemblage.

The mucus which has crystallized out is likely to be innocuous.

In the second class we have particles of mucus, which, as shown in fig. 5, present the appearance of ridges and cavities; but whilst remaining on the glass these do not alter in shape, except as the result of becoming drier: the cavities are produced generally by air-bubbles, but sometimes some fatty or oily matter would seem to be present.

In the third class, as shown in the lower part of fig. 4, and in the whole of fig. 6, we find the mucus neither remaining constant nor crystallizing out, but resolving itself into granules. Such granules readily separate from the glass, and, being blown about, might, if captured—their source being unknown—be mistaken for "germs" of some kind or other.

Granules of a like kind, but appearing separately, were observed in the atmosphere of a fever patient. As I believe them to be able to serve as the physical basis of contagion, let me state what occurred. The patient was a child who had been prostrated with infantile remittent fever of a typhoid type; after a severe sickness, he was recovering. At this time I had passed through an attack of coryza; and though the cold was over, there was some remaining delicacy of the membranes of eyes and nose. At separate occasions it was forced upon my attention, on visiting the convalescing fever patient, that there was some matter in his atmosphere to make me sneeze, my eyes to water, and the gravedo to return. There was a mere momentary impression of feverishness of the skin. This occurred on distinct occasions, and I considered it might be of service to make a micro-examination of this air; a great multitude of somewhat transparent granules were observed, and I have come to the conclusion that these were exudation granules; and that when strength begins to return, and they are exuded and breathed forth into the atmosphere by the patient, they form that

material which (being lately part of the patient's body) conveys the patient's malady to another person, in peculiar states of the system.

With respect to figs. 8, 9, 10, 11, 12, 13, and 14, they were discovered in the atmosphere of the Theatre Royal; fig. 8 represents merely inchoate dust and granules; fig. 9 is more interesting, for here we have a group of salivary corpuscles, and some fragments of epithelial scales, the group being formed by a drop of the condensed moisture of the breathing crowd. Figs. 10, 11, 12, 13 are fragments of epithelium drifting about by themselves; and amongst the granules of fig. 14 are likewise a few such fragments, whilst there are also some salivary corpuscles.

Where persons are compelled to breathe the excreted matter of others, conditions of disease become correlated with the frequency of this matter, but most especially with its liability to decay or putrefy.

VI.—Further Researches on the Atmosphere.—By George Sigerson, M. D., Ch. M., F. L. S. (Plates VIII., IX., & X.)

[Read June 13, 1870.]

Since my first paper upon this subject I have had the opportunity of reading Professor Tyndall's Lecture on "Dust and Disease." As he lectured on Saturday, and I on the Monday following, I had not observed any report of it in our Dublin Papers, and was somewhat at a loss, until I read it, to understand why Dr. Stokes should have considered me committed to the "germ theory" of disease. Professor Tyndall appears to regard it with favour; but I was not then the advocate, nor am I now, of a theory of "germs" (as hereafter defined), whilst maintaining that mineral, vegetal, and animal matter may produce, or communicate "disease."

Let me make one remark. There was some question raised concerning my statement, that I discovered in the air of crowds and cities muriate of ammonia in combination with mucus. Since then Dr. Angus Smith has found, by chemical examination, what he calls albuminoid ammonia, or ammonia of albumen, present in the air of Manchester. This I regard as a corroboration of my statement. In the June of last year, when getting some photomicrograms taken, one of my chief reasons for resorting to photography was in order to have a faithful portraiture of the exquisite arborescent crystallization-forms of the ammonia muriate. Professor Tyndall, in writing to me, observed: "It is to be hoped that through the researches of Dr. Angus Smith, yourself, and others, some definite knowledge will be arrived at regarding those particles, germs, and otherwise, which my experiments merely reveal *en masse.*"

There was no better means of attaining a correct knowledge (it seemed to me) of what is usually and what is occasionally present in

the air than by making a careful examination of particular atmospheres, as well as of the general air. A commencement was made in my former paper, when I made the broad divisions of "city air," "country air," and the "sea breeze"—and added to them the more limitedly special air of our dwellings. The examination of special atmospheres has since engaged my attention.

My mode of operation, here, has been to collect the sediment of the atmospheres, from ledges where it was deposited on a level with or above the height of man. In this way, making also an inspection of the air, I was certain to obtain matter identical with that which he had taken into his lungs. When this was done, I examined the collections with care in the microscope, applying suitable tests, and employing various object-glasses from the one-inch to the one-eighth inch. Some particles I measured with the micrometer. Then, when magnified generally with the one-eighth objective, I drew them on paper to the same apparent size; these portraits I next vastly enlarged for the diagrams which I have placed before the Academy.

Iron Factory Air (Plate VIII.).—The deposit was taken off rafters, about twelve feet high above the clay floor. It was black and friable. Microscopically examined, it was found to consist of carbon, ash, and iron balls, of the relative sizes shown. The carbon formed the largest masses, next came the ash, and finally the iron; the extremely minute dust of this dust was, however, the powder of carbon and a little ash. The carbon, large and little, was to be identified by its hue, and in some cases by its fibrous character; the ash was reddish, or white, and opaque. Some of the finest powder of the dust might be of from $\frac{1}{100,000}$th to $\frac{1}{300,000}$th of an inch in diameter.

Besides the substances already mentioned, there were transparent particles having a glossy fracture, and presenting the appearance of glass. I believe them to be actually particles of glass, formed in the furnace by fusion of sand flung in to assist in the operation of welding.

On making a minute examination of the iron balls, or, more strictly speaking, of the balls of ferroso-ferric, or magnetic oxide of iron, I discovered that they are, in fact, hollow spheres—iron balloons—which break readily on being pressed between two glasses. Then I found, on looking at one of the fragments, that the iron here present, was translucid You could see the light through it; and in it I detected a granular structure. I believe the translucency of ferroso-ferric oxide has never before been recorded. On making a measurement of these iron bombs, they were found to vary from $\frac{1}{300}$th of an inch to $\frac{1}{3000}$th. The general size was from $\frac{1}{2000}$th to $\frac{1}{3000}$th. Comparing the diameter of the bomb with the thickness of its shell, I came to the conclusion that in some, at least, the thickness of the shell was $\frac{1}{16}$th of the whole diameter. In a bomb $\frac{1}{3000}$th of an inch in diameter, the thickness of the shell might be taken as $\frac{1}{30,000}$th of an inch. This calculation I made in order to try to find at what thickness iron becomes translucid.

There were no spores or seeds present—no fibres of any kind, the result of spores developing—no fibres except of carbon, some contorted

branchy bits of iron, and a few cotton fibres, which came, no doubt, from the artizans' shirts. There were no germs here; yet the sunbeams were full of dancing motes, whose portraits I have given. The ray shining on them assumed, in consequence of their hue, a bluish colour, similar to that observed when the carbon smoke of a lamp or candle is placed in the sunbeam. The magnet attracted the balls and carbon, as shown on Plate.

On entering such an atmosphere the taste of carbon, and indeed of iron, may be readily perceived. The dust might serve as a cheap stomachic for those who use charcoal biscuits and charcoal and bismuth powder.

Effect on Health.—Although a great quantity of this iron, carbon, and ash, must daily pass in and out of the lungs, and, besides, although a certain percentage must remain, I have rarely found a healthier body of men than those who work in such factories. In one case a young man, whose lungs were weak, suffered from hæmoptysis [blood-spitting, with cough], which he had contracted in an American brass foundry where the heat was excessive. I found him in an air murky with these motes, and asked him did it not affect him. He said, no; he found himself well in it; his cough came on at home on rising and lying down.

Shirt Factory Dust (Plate VIII.).—This is a light-brown dust, interspersed with visible fibres. It was collected on ledges on a level with the breathing of the work girls, observed floating in the air, and seen deposited on the heating pipe, about twelve feet high.

Microscopically examined, the dust itself was found to be composed of filaments of flax and of cotton, together with minute fragments of the same of a very great variety of size. There were some flat fragments of cotton testa. All the flax and cotton fragments were whitish under the microscope, with the exception of a few red-tinctured particles. There were found in some of the dust, gathered off the casements, little eggs, some $\frac{1}{750}$th of an inch, and others $\frac{1}{3000}$th, with different sizes between. Some clusters contained large and small eggs, thus showing that the same parent may produce different sizes. Some were round, others oblong; they were generally transparent; a few were tawny. As they were found on the window ledges, they cannot be regarded as general constituents of the dust.

The *effect* of this dust is to make the work girls use snuff. A friend told me that, finding a crowd of them clustered round a grocer's shop, he observed to the shopkeeper that he presumed they had come for their tea. "You are mistaken," was the answer, "'tis for their snuff. They nearly all take snuff." The reason of this is obvious; and it is fortunate for them that this fibrous dust is not present in great quantity. Other workers are less fortunate—cases of embolic phthisis then occur.

Threshing Mill Dust contains fibres and fragments of the grain stalk and chaff, together with some smut balls. It would be an injurious atmosphere if it were habitually used; but the season of threshing is usually brief.

Oat Mill Dust.—Fibres are here present in greater number than I had expected; for, indeed, I hardly expected any. Fragments of the pericarp of the caryopsis or grain, as well as plenty of starch granules, are matters of course. Some spores may be occasionally detected, but not usually. Some acari or mites were present in the dust, and they rapidly generate in the lower contents of meal barrels. The mill air, the workmen assured me, had comparatively little dust in it, and was vastly superior to the atmosphere of flour mills, which, filled with lighter dust similar in kind, was exceedingly trying, and, in fact, very injurious.

Scutchmill Air.—The dust is light-brown, spongy; fibres and fine dust present. Scutchmills, as generally found, I must declare to be human slaughter-houses. The atmosphere is thick with dust, or "stoor," of the very worst character; for it is filamentous from the presence of long, fine branching liber cells, which help to stuff up the lungs; and it contains a great quantity of broken wood fibre, whose sharp points and brittle hardness must tease and irritate them.

The *effect on health* is very bad. When a workman first joins, he feels, for the first week, as if about to die from great oppression in breathing, sick stomach, and headache. He gets, however, somewhat used to the work, but soon his emaciated look indicates ill health; and it is a general saying that "scutchers die young."

The "stoor" I have seen in mills where the scutching was done on the old and on the new systems—in the latter case the slaughter might readily be greatly diminished, and almost altogether prevented. The machines should be so covered as to prevent the "stoor" from pouring forth in front; it could and should be sent backwards out of the building, away from the workers. Those who have charge of the inspection of factories should extend their range of observation to the sanitary conditions of mill workers.

Printing Office Air.—Brownish dust, few fibres, collected on rafters eleven feet high. From a statement made to me by an intelligent printer, that, when stereotyping was being accomplished, he sometimes experienced nausea, I suspected the presence of antimony in the atmosphere. Types are now composed of lead and antimony, the latter substance being added to harden them. Boiling water is usually dashed on them to cleanse them of ink, and to dry them; in this way some antimony might be volatilized. The movement of the types whilst they are being handled helps to reduce portion of their substance to dust.

At my request, Professor W. K. Sullivan was kind enough to make a chemical analysis of printers' dust—taken from rafters eleven feet from the floor—and there, in fact, antimony was readily found. There was iron also, which possibly came from the machine room, or the metal bars of the skylights.

Antimony, being diaphoretic and sedative, may probably produce little or no injurious effect, considering the small amount of it present in the air to be inhaled. Although many printers keep healthy and

grow old, and nearly all escape the diseases that troubled them when the types were made of lead only, still the trade is regarded as trying for boys; and bad legs are not unknown. In some instances it would appear that the needless and harsh custom of compelling a standing posture whilst at work may be an efficient cause.

In the atmosphere of *type foundries*, and in that of *stereotypers*, the antimony is likely, however, to be present in quantity sufficient to affect the constitution of operatives.

Stable Air (Plate IX.).—The deposit on a beam seven and a-half feet above the stable floor was brownish in colour, and somewhat tenacious, from the presence of long fibres. Microscopically examined, I found that almost all this atmospheric sediment was of animal matter. There were a few moth scales, a few ovules, some of them probably of moths. I found a small whitish larva encrusted in a sheath of agglutinated dust, and an acarus, different somewhat from those described. It was in colour whitish; its legs were not red, but white; hair decidedly simple, not feathered on legs; that from the body was apparently jointed like *Equisetum*. To a morsel of rent cotton fibre, that came from the groom's shirt, no doubt, were accidentally attached a couple of small heads of minute fungi, a species of Botrytis, resembling *Botrytis urticæ*.

Fragments of the fine horse hair were common, and there was a multitude of cuticle cells sent about in the atmosphere when the horse was being currycombed and brushed.

Grooms who do not continually abide in such an atmosphere probably escape without any particular hurt; though sometimes it is evident they may get awkward matter into their lungs. As it is manifest that *barbers* must live in an atmosphere very closely resembling this—with human cuticle, scales, and hair present, instead of equine—I took an opportunity of inquiring about their diseases. I found that they suffered rather usually from chest complaints, and that the "machine," or rotatory brush, whirls off a dust of no pleasant character, about the level of the breath.

Dissecting-room Air (Plate IX.).—The next atmosphere to which I shall draw attention is that of the dissecting hall. The dust was taken from ledges from seven to eight feet high. It was dark-brown, and somewhat tenacious, with some fibres. Microscopically examined, I discovered in it fragments and fibres of white fibrous tissue, of yellow fibrous tissue, fibrillæ of striated or voluntary muscle, and of non-striated or involuntary muscle. Treated with nitric acid, the latter corrugated in a characteristic manner. Besides these, there were fragments of cuticle—epithelial scales—inchoate particles and corpuscles of various sizes. Some appeared to be fat cells, whilst some others may have been blood corpuscles. There were a few fragments of hair.

This is a somewhat ghastly revelation. Nevertheless, it is better to have the truth known, when precautions, now neglected, may be taken. It is clear that it would be perilous for students with abraded or diseased lungs to undertake the study of anatomy. It has been said,

that puerperal fever may be occasioned by the attendance of a physician fresh from the dissecting room. Doctors, consequently, take the precaution of changing their clothes. But if it can be so caused, they should likewise take care to cleanse their lungs with a sufficiency of fresh air. Dissecting halls should also be disinfected daily—an operation that might be performed by the attendant sprinkling the floor with a disinfecting fluid before he sweeps it.

Tobacco-smokers' Atmosphere (Plate X.).—In order to get the microscope to bear upon smoke—to investigate the smoker's atmosphere—I was compelled to fashion a flat glass tube, through which I drew the smoke. There was a rapid deposit of the hot products of distillation, in oily globules, on the glass; yet, in spite of this, and in spite of using merely a small habitual cigarette, I became excessively sick, and had to lie out in the open air. By careful management, however, I at length got a thin layer of smoke into focus, and there beheld the globules moving and twirling about like a host of monads. These globules, consisting of nicotine and other pyrogenous oils, were to be found, not only in the smoke drawn in, but also in that emitted; but very little was detected in the saliva. Some, no doubt, had been deposited on the walls of the mouth, as was seen on the glass; but the moistened walls may not have retained so much. When the smoke enters the lungs, vastly more globules are retained; and hence the sickness of the beginners, who do not know the art of smoking; hence my own sickness, when in experiment I was forced to inhale the smoke.

These globules of nicotine, floating about to form the smoker's atmosphere, are not necessarily inhaled by him, unless the smoke be dense, as in a close room; but often they may be inhaled by his non-smoking companion. Hence, the nausea of the latter. Drifting about in the atmosphere, the globules deposit themselves on the clothes and curtains, and communicate to them an intense smell of tobacco. However, if, whilst floating about in the air of cities, they are caught by amateur investigators, another fate is, perhaps, reserved for them. They may be regarded as germs; and as they will resist the iodine test for amyloids, and are evidently organic, the supposition might be considered proved absolutely, and thus a passing smoker may delight the panspermists with myriads of germs.

Finally, I take the *Tea Tasters' air* (Plate X.). Tea tasters are men who, in the establishments of large wholesale tea merchants, are engaged to select and set apart teas, by taste. Their constitutions are impaired, their lives abridged by this perilous occupation, but their salaries are high in proportion to the risk. Why is this business so dangerous? When the teas are drawn, and poured in a range of cups, the tea taster proceeds to his work. To estimate their quality, he must not be soon after a meal, or his taste will be vitiated. If he be fasting, so much the better—if he can endure it. He takes the cups in succession, and placing each to his lips takes, not a sip, but a whiff of tea—a sip with a sudden swift inhalation. By that means, a fine

shower of tea passes against his palate, giving him a keener taste, but some of this shower passes with the inhaled air down into the lungs.

In order to detect what entered, I vapourized the tea with a perfume vapourizer, and thus found that the drops assumed a round shape. On microscopic examination of these, and of tea not so treated, I discovered a considerable quantity of particles of cellular tissue, and some portions of fibrous tissue. These might assist to tease the lung, but could not produce the vehement effects I have known to be produced. But, besides these, I discovered a number of bright globules of oil—the narcotic oil of the tea leaf, interspersed through the fluid. This it is, undoubtedly, which causes the nausea and nervousness that afflict tea tasters. These effects are quite analogous to those produced by the nicotine of the tobacco; and I have heard of cases where smokers, deprived of their accustomed weed, found some solace in smoking tea leaves. So treated, they yield a faintly yellowish oil, which leaves on the paper of a cigarette a yellowish stain, and an odour some have mistaken for tobacco.

The effects on the health are, as I have stated, very serious. Nausea, biliousness, dyspepsia, nervous irritability, occur, and one or other may become habitual. Syncope or fainting occasionally happens. Thus, a friend mentioned to me that he was present in a London tea store, when one of the proprietors of it entered. He had been accustomed to act as tea taster, but his physician had prohibited him, on account of his health. The tea cups were on the table, and he approached; but his partner warned him not to taste, but to obey the prescription. He looked healthy, and felt himself recovered, and thought he might venture. He had no sooner tasted one or two cups, says my informant, than he fell as if he was shot. He had fainted. Assam tea, I was told, is the most severe; and on examining it, I found a large quantity of this oil.

The remedy would be to prevent the tea from going into the lungs. The tea taster should endeavour to manage as the smoker does, with as dangerous a servant. If a sip or a mouthful be found insufficient, though with care better might be expected—if, however, he must still persist in the whiff, let him at all events take in a full breath before he taste. He will then have a volume of air stationary in the lungs, thus preventing a draught to the farthest pipes; and this air, being expelled when the taste is taken, will blow out the greater part of the globules, which otherwise would have rested in the lining of the bronchi.

From the above observations and my previous investigations, I believe myself justified in drawing the following conclusions:—

Firstly—That stomach signs—irritability, nausea, dyspepsia—may be in reality, and not unusually, symptomatic of interference with the lungs. Both lungs and stomach are supplied by the branches from the pneumogastric and from the sympathetic systems. To treat the stomach, in such cases, may obscure the symptom, but will not cure

the disease. The indication would rather seem to be to cleanse the lungs by inducing a mucous discharge.

Secondly—That the lungs have a power, not hitherto suspected, of absorbing or assimilating even solid matter. It is clear from what I stated of Pouchet's anatomical discovery of objects in the air pipes, as well as from Professor Tyndall's experiments, that a considerable quantity of matter frequently and generally remains in the lungs. Some may be got rid of by mucous discharges; but evidently all is not thus usually expelled. Some of the carbon and iron in the iron factory dust no doubt remain; and, unless the lung is to be clogged up, it must dispose of them somehow by absorption. Old lungs get a grey colour from the dust they absorb. It does not appear more difficult for the lungs to do this thing, than for the delicate fibrillæ of the roots to accomplish it. It may be remarked that carbonic dioxide acts as a solvent in many cases, and that in the lungs are carbonic dioxide, oxygen, and moisture, all which favour the dissolving act.

Thirdly—That the theory of panspermism seems unfounded on fact—that there are no hosts of germs *always* floating about in the atmosphere, invisible and maleficent as genii of Eastern stories. Air is not much better, but not generally worse than water. Professor Tyndall has set the sunbeam prominently before us; but I have come upon atmospheres where a sunbeam could not be seen, for want of motes. Within doors at a country place, in winter, the motes were plenty, and the sunbeam well defined; out of doors, in a calm spot, I could see the bright slit where the ray entered the bower: I could see the white spot on the floor where it fell, but between these two visible points there was no visible line. It was impossible to say where the ray was, until the hand was placed in its way, or a little dust shaken through it. The dust produced patches of visible light in this invisible ray, just as Professor Tyndall caused patches of stellar darkness by expelling dust out of his visible ray. This fact will, I hope, satisfy the talented editor of "Scientific Opinion," that Professor Tyndall's explanation was correct, and that conditions of polarization need not to be sought for.

Fourthly—The "germ theory" asserts, "That epidemic diseases are due to germs which float in the atmosphere, enter the body, and produce disturbance by the development within the body of parasitic life."* This is stated to be opposed to the opinion that epidemic diseases are "propagated by a kind of malaria, which consists of organic matter in a state of *motor decay.*" Now, for my part, I object to the claim of monopoly here set up. There is no necessary opposition; the action of one agency does not here exclude the action of another agency. There may be constitutional disturbance produced, both by the growth of spores and action of mucus particles.

The "germ theory" is supposed to be supported by the so-called fact, that "putrefaction is caused by germs derived from the air, which

* Professor Tyndall's Lecture on Dust and Disease.

could be destroyed by a sufficiently high temperature;" also by the statement that rotten malaria cannot act like leaven, because fermentation is caused by the growth of the yeast plant.

Now, the effect of the growth of parasitic plants in causing skin diseases is perfectly well known. I have shown, in my previous paper, how they may affect the lungs. Next, that no putrefaction or conversion of matter can occur in prepared solutions, hermetically sealed, was disputed by Pouchet, who adduced instances to the contrary, and has since been disputed by Drs. Bastiam and Frankland, with proofs present. For myself, on opening the dense shell of a cocoa nut, and cutting through its oily albumen, I discovered in its milk a web-like plant—a kind of Achlya. I do not believe it probable that this Achlya got its "germs" from the outer air, but regard it as an example of convertibility of matter—and correlation of beings—what some call rather wrongly spontaneous generation. Again, a dissection wound shows, in its results, how rotten matter may act with the quickness of leaven. I would prefer to call this theory the theory of *motor change*, rather than of *motor decay*. It yet remains to be proved that the facile explanation of the growth of the yeast plant being the cause of fermentation is true—or, being true, is the only true one. Two different agents may produce the same effect. Gay Lussac and Liebig disbelieved its power. Pasteur, says Professor Tyndall, "finally exploded their views of fermentation." Nevertheless, with due respect to both these distinguished men, I must believe that the yeast plant can have no retrospective action—that it cannot perform nor influence work done before its birth. Now, before the wort is made, and the yeast plant developed, molecular change has really already begun. Its effect is the difference between malt and raw grain. Starch has been altered into dextrine and sugar, without the yeast plant—which may or may not assist by its growth or by its decay (as some think) to continue the alteration until alcohol and vinegar be produced. In the castor oil and colza seeds, Fleury found that the fatty matter was converted into dextrine and sugar, by fixation of oxygen—without, remark, the assistance of the yeast plant. Payen and Persoz believed the change to be owing to azotized *diastase;* later observers have shown that it can be effected, under suitable circumstances, by any albuminoids, themselves being partially altered by the action of oxygen at a certain temperature, with moisture present. Now, I have shown, in my previous paper that mucus particles—the excreta of man and animals—are present at times in the atmosphere—that a great increase of granules resembling exudation granules was present in the atmosphere of a patient seized with infantile remittent fever of a typhoid type. In these you have the requisite albuminoid substance present. And I am convinced that it depends on whether or not this or other albuminoids—animal and vegetable—be in a state of motor change, to furnish us or not with that contagious matter, whereby diseases are most commonly engendered and communicated.

VII.—ON AN OPTICAL METHOD BY MEANS OF WHICH THE FORMATION OF DEFINITE CHEMICAL COMPOUNDS MAY BE IN CERTAIN CASES DETERMINED. By THE PRESIDENT. [Abstract.]

[Read February 14, 1870.]

THIS method is based upon the power which solutions of the vegetable alkaloids generally possess, of rotating the plane of polarization of a transmitted ray, and the change effected in this power when the alkaloid is converted into a salt.

Applying this method to the combination of nitric acid with quinia, he showed that the formation of an acid nitrate (or bi-nitrate) was clearly indicated.

VIII.—NOTE ON A PROPOSED NEW METHOD OF DISPOSING THE BAROMETRIC COLUMN SO AS TO FURNISH DIRECTLY ENLARGED INDICATIONS, WITHOUT THE INTERMEDIARY OF A SYSTEM OF TRANSMISSION OF MOVEMENT. By J. P. O'REILLY, Esq., Professor of Mining and Mineralogy, Royal College of Science. (Plate XI.)

[Read February 28, 1870.]

HAVING been led to examine the question of the arrangement of a barometric column capable of rendering clearly perceptible minute variations of the mercury, I was led to imagine, and have had carried into execution, the plan which I beg leave to submit to the Academy, and which I purpose to explain in the following note.

The ordinary barometric column undergoes in our latitudes an extreme oscillation of about 1½ inches, and consequently small variations cannot be rendered clearly perceptible to the eye, however accurately they may be measured by the instrument.

On the other hand, the wheel barometer, so ordinarily in use for observations in connexion with changes of weather, is defective, by reason of the system of transmission employed for communicating the vertical movements of oscillation of the mercury to the dial index; its indications have, however, the advantage of being very perceptible, and, so far, have a special utility. The problem which I considered was, the combination of the exactitude of the vertical column with the distinctness of indication of the wheel barometer, without the intervention of any system of transmission.

My first idea was the establishment of the column in an inclined position, so that the mercury, tending to rise or fall through a certain vertical distance, in consequence of a change of pressure, should be obliged to traverse a length of inclined tube proportional to its inclination from the vertical. In this manner the extreme length of oscillation of the mercury might be doubled, at least, and consequently more minute variations rendered observable. Subsequently, on exa-

mining the arrangement required for the basin of the instrument, I was led to that which I now submit, and by means of which the atmospheric pressure causes the column to oscillate about an axis of suspension, precisely as the beam of a balance, and, moreover, to mark the amount of oscillation by means of an index attached to the column, precisely as the index needle of the beam balance does when oscillating. In other words—I attempt to weigh the atmospheric pressure by causing it to act at the extremity of a beam, suspended on an axis of revolution, and counterpoised at the other extremity by an invariable weight. It is, therefore, to all intents and purposes, a beam balance.

I have endeavoured in the annexed drawing (Plate XI.), to show the method of arrangement which a first trial had led me to adopt for the better attainment of the proposed result; and in the course of my note I shall have other modifications to submit, which I conceive would tend to insure more satisfactory results. But the drawing and the model, or first practical attempt exhibited, will prove, I hope, sufficient for a complete explanation of the idea. I shall first consider the model as representing the original plan. It is clearly to be understood that it was intended rather to test the fundamental principle of the arrangement in the simplest manner possible, than to represent the idea in a complete form; and that, therefore, it in no way pretends to those conditions of correctness or delicacy which I believe may be attained by a more careful execution and better arrangement of the component parts.

The model consists essentially of four parts—the tube, partly of iron, and partly of glass; the basin of reception for the mercury, made of wood, cubical exteriorly, and cylindrical interiorly; the tube penetrates into the basin, and should rest on the opposite part of the interior cylindrical surface; the basin is not completely filled with mercury, but sufficiently to insure that the open end of the tube remains covered by the mercury within certain limits of oscillation of the column from the vertical. The facility of oscillating is secured by means of two bearings placed on the axis of the cylindrical cavity, and attached to the sides of the wooden basin. If the basin alone be considered, it is evident that in any one position it may assume, by turning on the axis, it is in equilibrium, provided the centre of gravity of the system is below the axis of suspension. If now it be considered in connexion with the column of mercury, it is evident that this state of equilibrium will be maintained, provided the weight of the column be so counterpoised as to reduce the position of the centre of gravity of the combined parts to the position already indicated as regards the axis of revolution.

Now, if it be imagined that the column thus counterpoised, and suspended on an axis of revolution, have its centre of gravity close to the axis, an increase of atmospheric pressure, by acting on the mercury in the basin, causes it to rise in the tube, and displaces, therefore, the centre of gravity of the system. The centre of gravity rising to the level of the axis of revolution, or above it, as the case may be, tends to

cause a disturbance of the state of equilibrium, and therefore to cause the column to fall away from its original vertical position; and the extent of angular derangement of the column would necessarily be proportional to the extent of rise of the mercury. The mercury tending to fall, the column would tend to regain the vertical, and reassume its previous state. But, as the column would thus tend to fall indifferently to the one or to the other side, it naturally suggests itself that an appropriate arrangement of the counterpoise, would cause the column to remain on one or other side of the vertical in its limiting position, and thus oscillate entirely on that side of the vertical. Again, in order to measure the extent of oscillation of the column from this limiting position, there is merely requisite an index needle attached to the basin, and which may be made to combine with the counterpoise so as to determine the initial position of the column as regards the vertical. The arcs described by the extremity of this index needle on a graduated scale, appropriately situated, will then measure the extent of the oscillation, and therefore can directly indicate the corresponding barometric pressure.

Such being the general principles of arrangement of the proposed system as represented by the model, there remains to be shown the particular advantage which I believe may be insured by it, and to explain such a more appropriate arrangement of the different parts as would allow of its being constructed so as to fully insure that advantage.

It is evident that the sensibility of the instrument will depend—

1st. On the total weight bearing on the axis of suspension;

2nd. On the length of the glass tube;

3rd. On the angle of limiting position as regards the vertical.

The length which may be given to the index will, of course, influence the distinctness of the readings.

The total weight bearing on the axis should evidently be reduced as much as possible. Now, as the essential element of weight in the instrument is the mercury, it is evident that by limiting the diameter of the column, and the consequent volume of mercury necessary to fill it, this object may be best attained. On the other hand, as by the very nature of the proposed method of reading the meniscus ceases to be of importance, it is evident that the diameter of the tube may be advantageously reduced. As, however, the glass tube must have a certain thickness independent of the interior diameter, it is clear that the limiting bore will be that which can be obtained with the least thickness of glass, capillarity being avoided. A tube of from five to eight millimetres interior diameter would, perhaps, be a convenient size to construct with. As, moreover, the length of the tube must be taken into consideration in the working, since it must admit of a certain amount of handling, it is evident that a smaller diameter than five millimetres can with difficulty be employed for such a length.

The diameter being thus reduced to a minimum, the volume of mercury is proportionally reduced, and consequently that of the cylin-

drical basin as a recipient; the weight of this is, therefore, also reduced, as well as that of the counterpoise of the column.

The length of the column capable of insuring satisfactory indications can hardly be determined *à priori*. The greater this length, the larger the angle through which the column may move, and consequently the more extended the arcs to be described by the index point, as marking the amount of variation; but, practically, there can only be a certain length of tube which will be safe for handling and working with; while the drawing of very long tubes of a small diameter would perhaps present considerable difficulties. A tube of about 1^m, 50, say 5 feet, would probably be about the limit that might be usefully employed.

The limit of length at once fixes the limit of angle of oscillation of the column, since for this limiting position the mercury will completely fill the tube.

This angle of oscillation at once fixes that of the index.

This again must evidently count as part of the counterpoise, and consequently its weight is so far defined. Its length may, however, be evidently increased within limits corresponding to this weight. Its extremity may thus be made to describe an arc multiple of that described by the summit of the column. And, as this result can be attained without necessarily throwing additional weight on the bearings, it presents a decided advantage, as far as distinctness of observation is concerned.

The angle of limiting position, as regards the vertical, is evidently one which must depend very much on the total weight acting on the bearings of the axis. For positions very near the vertical (say 10°), and a low pressure of the atmosphere, the tendency of the column to incline under an increasing pressure would be comparatively slight; or, in other words, the column would be sluggish. For a greater angle (say 30°), the action of an increasing pressure would be more marked, the leverage being greater; but the total amplitude of oscillation would be so far reduced, the length of the tube being taken as limited.

The consideration of those several influences leads me to submit the following modifications for the construction of a barometer to work on the proposed principle.

The tube to be conical, not cylindrical. Evidently any other variation from the cylindrical form could with difficulty be practically realized, whilst a conical tube can be drawn to answer the required conditions of diameter. For the portion which would correspond to the ordinary vertical height of the mercury, the cylindrical form might be retained, since the volume of mercury occupying this space remains constant for all positions; the remainder of the tube to be made conical.

The degree of tapering or conicalness should be such as would insure regularity of movement of the column, independently of the angle of inclination from the vertical. With a cylindrical tube, the displace-

ment of mercury becomes rapidly great, the angle of inclination increasing the level in the basin is proportionally altered, while a nice adjustment of the counterpoise can hardly under these circumstances be attained; the extreme angular displacement must be avoided, and therefore, the total angle of oscillation is so far reduced. On the contrary, by adopting a conical form for the portion of column above 0^m, 80, such a modification of the displacement of mercury as may be considered advisable can be attained, regularity of motion be insured, the volume of mercury in the basin reduced, and its level more persistently maintained; while, finally, an extreme position of the column will not present serious inconvenience, and the maximum angle of oscillation will be insured.

The points of suspension might be steel screw points, working on agate cups.

The counterpoise proper might be made long proportionally, so as to reduce its weight.

The arrangement of the index and counterpoise symmetrically with the axis of the tube, as in the drawing (Pl. XI.), would be the best, since space would thus be allowed for an orifice in the basin on the axis of the column, by means of which the mercury could be introduced or removed with facility.

The diameter of the basin is such that the open extremity of the open tube remains covered for an extreme position by at least 4 centimetres deep of mercury, while the length of the basin is supposed to be such as will reduce the total variation of level of mercury, to about 5 centimetres; of course, if desirable, a greater length may be adopted, so as to reduce this variation still more.

It is unnecessary to remark that such an instrument presents the great inconvenience of requiring considerable space, and would require, equally as a balance, to be closed in from dust, air currents, &c., so as to insure precision and delicacy. But, admitting these inconveniences, and the defects inherent to a rough idea, there remains the advantage of a direct system of indication without the intervention of any transmission whatever, as also that of allowing the scale of indications to be considerably extended, by a simple increase in length of the index, without in any way increasing the weight of the instrument, and therefore either altering its delicacy or diminishing its sensibility of movement. Such an instrument could only be adapted for public buildings where barometric observations have a direct practical value, such as those connected with the service of ports, and where small variations of pressure may have great significance as regards weather forecasts. For such uses, there is a direct interest to render the observation of the Barometer at once distinct and marked, and the indications easily legible for the ordinary eyesight.

In connexion with this question, might I not suggest that the atmospheric pressure in pounds to the square inch, or in kilogrammes per centimetre square, be shown on the scale of the Barometer, instead of a vertical height of mercury in inches or millimetres. Of

course, this height and the pressure are convertible terms, but for the sake of precision as also for the more distinct instruction of the public, the double indication would perhaps be preferable. As moreover, the Barometer is intended to measure a weight, there would be a certain propriety in distinctly showing the nature and amount of weight measured by it.

As the cylindrical form of tube presents very great advantages, by reason of its regularity and the facility with which it can be obtained, there would appear to be a certain advantage in employing it for the barometric column. In this case it is evident that a counterpoise of fixed weight cannot insure regularity of movement and a due control of the extent of oscillation. To remedy this inconvenience, I would propose for the cylindrical tube that the weight of the counterpoise be rendered variable, proportionally to the increasing volume of mercury in the column requiring counterpoise. This may, I believe, be effected very simply, and with any degree of precision, by suspending in the plane of oscillation of the counterpoise, and immediately over it, a chain formed of transverse bars, whose length, and therefore weight, can be varied according to any arbitrary graduation, while the degree of curve or deflexion from the straight line would be equally under command. If now it be supposed that the counterpoise in rising come in contact with this chain, it will be loaded, progressively with its rise, according to any desired law of increase of weight; so that the increases of weight on the one side of the axis can be perfectly counterpoised on the other, or so counterpoised as always to insure action of a constant deflecting weight, whatever the degree of inclination from the vertical. In order, moreover, to increase the extent of the indication on the graduated scale, it would be possible to establish two columns in juxtaposition—that is, having their axes of suspension on the same line, but arranged, as regards their counterpoises, so as to oscillate on opposite sides of the vertical. The indicators would thus open out like the legs of a pair of compasses; and the extent of arc lying between their extremities would represent the double of the real indicators, giving a *mean* reading, and therefore doubling the accuracy of the instrument.

IX.—Addition to the Note on two Streams flowing from the same Source in Opposite Directions.* By Professor Hennessy, F.R.S., Vice-President.

[Read March 16, 1870.]

In describing the flow of two different streams from one source, in my Note published in Part iii., vol. x. (Ser. i.) of the "Proceedings," I anticipated that the phenomenon which I had observed during very dry weather would become clearly manifested after heavy rains. This anticipation has been recently verified by Mr. R. A. Gray, C. E., County

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* Vol. x., p. 335.

Surveyor for the southern division of the county of Dublin. Mr. Gray was passing through Glencullen on Wednesday, the 9th of this month, when he noticed that great quantities of snow were melting on the sides of the mountains, and that the streamlets were filled to overflowing. It immediately occurred to him to look at the water parting, to which I had called the attention of the Academy, and which it appears he had previously noticed; and he there saw the single feeding stream from Glendoo rushing down in great volume, and the two bifurcating streams parting from it and from each other in the most palpable manner. The abundance of water was such as to partly flood the adjoining road. Mr. Gray is decidedly of my opinion, that the beds of these streamlets are not due to artificial cuttings, but are the result of the physical conformation of the glen.

X.—NOTE ON THE HORNBLENDE AND AUGITE GROUPS OF MINERALS. By WILLIAM K. SULLIVAN, Ph. D., Secretary of the Academy.

[Read April 25, 1870.]

NEXT to the feldspar group, the hornblende and augite groups are the most important, from the point of view of lithology and petrography. The minerals included in these groups belong to the same crystalline system, but to different crystalline series; in chemical composition they approach so closely that the typical varieties of each group may be represented by the same general formula; and, lastly, the minerals of each group belong chemically to two classes—1. silicates of the dyad metals, magnesium, calcium, iron (ferrosum), and manganese, or simple augites and hornblendes; 2. the aluminous augites and hornblendes. The nature of the relationship of these groups has not yet been clearly established, while the nature of the aluminous silicate or rather silicates, and the way the latter are present in the mineral, are still obscure. Having occupied myself with the study of these groups for some time, though in consequence of other occupations in such a desultory way, that I have not been able to bring the inquiry to a satisfactory conclusion as yet, I am induced, chiefly in consequence of a recent memoir of Herr Tschermak, in which he has incidentally stated his views upon the two points just stated, to briefly lay before the Academy the conclusions to which my study of the groups lead me upon those same points.

Dr. Tschermak, who has been so successful in unravelling the difficulties of the feldspar group of minerals, states in his prize essay on the porphyritic neozoic rocks of Austria,* that typical hornblende, as represented by tremolite, has the formula $Ca''Mg_3''Si_4O_{12}$; and typical augite, represented by diopside, the formula $Ca''Mg''Si_2O_6$. He considers that the aluminous hornblendes contain, in addition to the

* Die Porphyrgesteine Oesterreichs aus der mitleren geologischen Epoche Wien, 1870.

meta-silicates of the dyad metals, the two silicates $Ca'' Mg'' Al'''_4 Si_2 O_{12}$, and $Na'_2 Al_2 Si_4 O_{12}$; and aluminous augite, in addition to the meta-silicates of the dyad metals, the silicate $Mg Al_2 Si O_6$. The latter may be considered as the magnesian part of the first of the two silicates of alumina in aluminous hornblendes.

I shall first consider the relationship of the two groups, which the formula of Dr. Tschermak would more or less disconnect. Meta-silicic acid and meta-silicates, like meta-phosphoric acid and the meta-phosphates, readily form condensed molecules without the loss of atoms. The series of condensed bodies thus formed are, therefore, polymeric, or simple multiples of the first or type acid or salt. They are merely a number of similar molecules, riveted together into more complex, but still similar molecules. All the members of a polymeric series of acids, or of salts of the same base, are doubtless strictly isomorphic;* the members of a condensed series of salts containing different isomorphic bases must also be isomorphic within certain limits. If the typical salt of any polymeric series of salts of the same base be dimorphic, the dimorphism should extend to the whole series. In the case of condensed salts containing different bases, a special case of dimorphism may arise, which has not been heretofore noticed. Let us suppose the basic elements in such a series of condensed salts to be the dyad metals, magnesium, iron (ferrosum), manganese, and calcium, and the salts to be meta-silicates. The forms of the molecules of magnesic and ferrous meta-silicates must more nearly resemble each other than either of them does the molecule of calcic meta-silicate. At least, this is probable from the analogy of the magnesic and ferrous sulphates, which crystallize with seven molecules of water, while the molecule of calcic sulphate takes only two molecules of water. Meta-silicate of manganese should form the link between the magnesian and ferrous salts on the one hand, and the calcic one on the other, if we may argue from the sulphate, which can crystallize with seven molecules of water, and with two. We should find this difference manifest itself in the angles of the forms of the salts, according as magnesium or calcium predominates. That is, the condensed salts containing much magnesium should crystallize in a different crystalline series from those containing a larger amount of lime. Although slight variations in the values of the angles and modifications of angles or edges of the crystals always accompany changes in the chemical composition of bodies, the forms of one crystalline series never graduate into another. The limits of variation of the values of the angles of the figures of a series are very small, while the limits of change of composition consistent with the maintenance of the forms of a given crystalline series are very considerable. Thus, the form of ferrous sulphate remains unaltered, save in some slight variations of the angles, and in the character of the modifications, which of course belong also to the crystalline series of

* If exceptions to this rule exist, their study would throw much light on the structure of condensed molecules.

the pure salt, even when the crystals contain more than half their weight of cupric sulphate. When the limits within which the change of composition consistent with the maintenance of any given crystalline series are approached, the physical condition of the crystalline mass determines in which of the limiting series it shall crystallize.

The case here supposed is exactly that of the hornblende and augite groups. Both these groups constitute a polymeric series of condensed meta-silicates, which may be represented by the same general formula $(M''SiO_3)^n$, where M″ represents the dyad metals, magnesium, iron, manganese, and calcium. When the magnesium predominates—that is, when it is to the calcium in the ratios of about 3 : 1 or 5 : 2—the salts crystallize as hornblende; when the ratio of the calcium and magnesium is about 1 : 1, the salts crystallize as augite: manganese, being, as I have above stated, intermediate between the magnesian and calcian series, may predominate in crystals of either form—that is, it is strictly dimorphic, the Cummington manganese spar probably representing the crystalline series of hornblende, and rhodonite the augite series. Where the ratio of the magnesium and calcium lies between the two extremes—the hornblendic composition and the augitic—the crystalline form assumed depends upon the physical conditions under which the crystals are formed. We accordingly find in nature many examples of the simultaneous formation of hornblende and augite, which, at least in those cases which I have been able to analyze the minerals, approach very closely in composition. Thus, small black crystals of augite, of the form $\infty P . \infty P \infty . (\infty P \infty) . P$. have been found on, and partially enclosed in, black, elongated, somewhat rounded hornblende crystals of the form $\infty P.(\infty P \infty)\ oP . P$. from the black basaltic tufa of Czerlochin, in Bohemia.* Herr Hasenkamp mentions† the occurrence of similar crystals at the Pferdekopf, in the Rhöngebirge. I also found, many years ago, in the latter locality two or three hornblende crystals, with small crystals of augite projecting from the faces. The two kinds of crystals were nearly of the same composition. The converse of this phenomenon has also been frequently noticed. Thus augite crystals from Arendal are sometimes found with a number of hornblende crystals attached to their sides or impressed into them, and in some cases so penetrating the mass of the augite that the structure of the latter almost disappears. The beautiful green augite of Lake Baikal, in Siberia, known as baikalite, is sometimes permeated by white hornblende. Herr Sandberger has also described a case of a lustrous hornblende crystal projecting from a well-defined, dull augite crystal, from the basalt of Härtlingen. Augite crystals, with projecting hornblende ones, are common enough from that locality.

But by far the most interesting examples of the simultaneous formation of forms of the two series is the occurrence of augite crystals with a nucleus of hornblende, and of hornblende with a nucleus of

* Verhand d. Würzburg. phys. Gesellschafts, ix., 32.
† Blum, Die Pseudomorposen der Mineralreichs, 45.

augite. Gustav Rose* found at Nikolajewsk, not far from Miask, augite crystals which, when broken, had a nucleus of hornblende. The uralite of the same mineralogist is hornblende with an augite nucleus. Some crystals, looked upon as uralite, may almost be considered as examples of paramorphosis, the angles being those of hornblende, and the cleavage being apparently that of augite, with sometimes, as just mentioned, a distinct nucleus of the latter. The supposed uralite here spoken of approaches very close in composition to ordinary augite.

Although it is true that many specimens of tremolite may be represented by the formula $Ca''Mg''_3Si_4O_{12}$, and of diopside by the formula $Ca''Mg''Si_2O_6$, and that the proportion of magnesium relatively to the calcium is greater in hornblende than in many augites, the adoption of these formulæ, as typical formulæ of the respective groups, is not admissible, because they exclude the intimate relationship which the polymeric character of the dyad meta-silicates gives to the two groups. Polymerism is indeed so important a link of connexion, that we may consider all meta-silicates as forming but one family, divided into as many groups as there are crystalline series. No such link of relationship subsists between the condensed ortho or anhydro-silicates. Each member of a condensed series has a molecule differently constituted, and must consequently belong to a different crystalline series, as will be evident from the following table, representing the general formulæ of silicates of dyad metals :—

Ortho silicates.	Meta-silicates.	Anhydro-silicates.				
		I.	II.	III.	IV.	V.
$M''_2Si\,O_4$	..$M''\,Si\,O_3$					
$M''_3Si_2O_7$	..$M''_2Si_2O_6$	..$M''\,Si_2O_5$				
$M''_4Si_3O_{10}$	..$M''_3Si_3O_9$	..$M''_2Si_3O_8$	..$M''\,Si_3O_7$			
$M''_5Si_4O_{13}$	..$M''_4Si_4O_{12}$	..$M''_3Si_4O_{11}$	..$M''_2Si_4O_{10}$	..$M''\,Si_4O_9$		
$M''_6Si_5O_{16}$	..$M''_5Si_5O_{15}$	..$M''_4Si_5O_{14}$	..$M''_3Si_5O_{13}$	..$M''_2Si_5O_{12}$	..$M''\,Si_5O_{11}$	
$M''_7Si_6O_{19}$	..$M''_6Si_6O_{18}$	..$M''_5Si_6O_{17}$	..$M''_4Si_6O_{16}$	..$M''_3Si_6O_{15}$	..$M''_2Si_6O_{14}$	..$M''Si_6O_{13}$, &c.
$M''_{n+1}Si_nO_{3n+1}$	.$M''_nSi_nO_{3n}$	..$M''_{n-1}Si_nO_{3n-1}$	..$M_{n-2}Si_nO_{3n-2}$, &c.			

In the ortho-silicates the condensation is effected by successively adding the meta-silicate $M''SiO_3$ to an ortho-silicate; or, what is the same thing, any condensed ortho-silicate is equal to the simple ortho-silicate M''_2SiO_4, together with the condensed meta-silicate containing one atom less. Thus the ortho-silicate $M''_6Si_5O_{16}$ is equal to M''_2SiO_4 + $M''_4Si_4O_{12}$. The anhydro-silicates consist of the meta-silicates, together with one, two, or more molecules of silicic anhydride, according as they are more remote from the series of meta-silicates. Thus any anhydro-silicate of series I. may be considered as the meta-silicate having the same number of atoms of base *plus* one molecule of SiO_2; any one in series II. as the meta-silicate having the same number of atoms of base *plus* 2 Si O_2; and so on, an additional atom being added for each successive series. The meta-silicate series itself, on the other

* Reise, ii., 40.

hand, being formed by the successive additions of molecules of the primary meta-silicate—that is, any condensed meta-silicate is a simple multiple of the first. The relations of the three classes of silicates may accordingly be represented as follows, taking as the example the silicates containing six atoms of silicum in each class :—

$$\begin{array}{ll}
\text{Ortho-silicates.} & \{ M''_7Si_6O_{19} = (M''SiO_3)^5 + M''_2SiO_4 \\
\text{Meta-silicates.} & \{ M''_6Si_6O_{18} = (M''SiO_3)^6 \\
 & \text{I. } M''_5Si_6O_{17} = (M''SiO_3)^5 + SiO_2 \\
 & \text{II. } M''_4Si_6O_{16} = (M''SiO_3)^4 + 2SiO_2 \\
\text{Anhydro-silicates.} & \text{III. } M''_3Si_6O_{15} = (M''SiO_3)^3 + 3SiO_2 \\
 & \text{IV. } M''_2Si_6O_{14} = (M''SiO_3)^2 + 4SiO_2 \\
 & \text{V. } M''\,Si_6O_{13} = (M''SiO_3) + 5SiO_2
\end{array}$$

This table expresses very clearly what I have already stated, namely, that the condensed meta-silicates, being formed by the association of similar simple molecules, the condensed molecules must be isomorphic with the constituent simple molecules; while both the condensed ortho-silicates and condensed anhydro-silicates containing the elements of two different kinds of molecules, change with each degree of condensation.

The preceding table also explains the presence of free quartz in rocks composed of anhydro-silicates, such as potash or soda feldspars, which belong to this class of silicates; and the almost complete absence of quartz from rocks consisting chiefly of meta-silicates, or where they are present in any quantity, as in syenites, dolerites, &c. It also throws much light upon the mutual relation of the different minerals which are found asssociated together in nature,—a subject which I cannot now discuss.

I now come to the subject of the constitution of the aluminous hornblendes and augites. Both these classes of minerals contain in addition to the meta-silicates of the dyad metals, aluminum and, generally, one or both of the alkaline metals, potassium and sodium—the latter as silicates—and part, at least, of the aluminum also in that state. Crystals of aluminous augites or hornblendes always present uneven faces of cleavage, and the faces are frequently drusy, and weather irregularly—qualities which are characteristic of all heteromorphic crystals—that is, of crystals built up of different compounds, crystallizing separately in different crystalline series, but which, when mingled together, follow the law of one of them. These properties led Kenngott* and Frankenheim† to the conclusion that aluminous augites and hornblendes were mixtures of the pure minerals with alumina or some aluminous compounds. Is the alumina always present in the same state of combination—that is, does aluminous hornblende or aluminous augite always contain the same aluminous silicate? Again, is there only one such definite silicate? And, again, are the aluminous silicates of the minerals of the hornblende and augite groups the same or different? The whole problem of the constitution of the aluminous augites and hornblendes, with the exception of one point, is embraced

* Sitzungsber. d. Wien. Akademie, xii. 702. † Poggend. Annalen. xcv. 375.

in these three questions, which have been answered positively by Herr Tschermak.

The point not embraced in the three questions, just stated, is—whether the aluminous compound, or compounds, are present as heteromorphic ingredients in a state of mixture, or in a state of chemical combination, and may be discussed first. If all the constituents were combined into one compound, the crystallographic molecules, which such a compound may form, should be homogeneous, and, with few exceptions, perfectly similar; and hence the crystals should not exhibit the anomalous cleävage which is so characteristic of heteromorphic crystals. It is probable, therefore, that the dyadic meta-silicates are not combined with the aluminous compound or compounds. Foreign ingredients may be present in crystals in three ways: as distinctly crystallized endomorphs, recognizable by the naked eye, or by the aid of the microscope; as regularly or irregularly distributed impurities, not distinctly crystallized; and as uniformly distributed heteromorphic materials, not distinguishable by the eye or microscope, but the presence of which may be recognized by variations in the angles, the character of the cleavage and the faces, the inequality of weathering, &c.

The study of the endomorphs, or crystals of foreign substances enclosed in other crystals, is the first step towards answering the three questions put above. Such crystals indicate, if they do not absolutely tell, the nature of the foreign ingredients, which may be present in such a state as to be unrecognisable by the ordinary means. Under the term endomorph, we may also include the fine films which insinuate themselves between the cleavage planes, or fill up the fine fissures or cracks, which may be detected in many crystals by the microscope. The materials which fill such fissures, &c., is generally derived from what may be called the mother-liquor, out of which the crystals separated—whether of aqueous or igneous origin. The only endomorphs I need notice here are those containing alumina. I shall, therefore, pass over the crystals of many non-aluminous minerals which have been detected in hornblende and augite crystals; such as apatite, the frequent occurrence of which, I was one of the first to point out.

The aluminous endomorphs which are found most generally in hornblende crystals, are—feldspars of the orthoclase varieties, nephelin, cyanite, olivin, garnet and idocrase, mica and talc. Those generally found in augite are, feldspar, chiefly of the plagioclase variety, especially Labrador, but also orthoclase, nephelin, leucite, garnet. I shall mention a few examples of the occurrence of these endomorphs, by previous writers. Delesse* has described hornblende crystals from veins in the gneiss of St. Phillip, in the Vosges, which are obliquely intersected by microscopical veins of a feldspar, having a fatty glance. According to Sandberger,† needles of sanidin are frequently enclosed in hornblende crystals in the trachytes of Nassau. In the black opaque

* Annales des Mines, [4] xx. 165. † Poggend., Ann. lxxxiii, 455.

simple and twin crystals of augite of the form ∞P∞ . (∞P∞). P. from the lava of Monte Rossi or Etna, there are sometimes wholly or partially enclosed smaller twin crystals of Labrador feldspar.* Wedding† observed under the microscope, occasionally, colourless transparent prismatic needles, rounded at the end, and cut perpendicularly to their length, by what appeared to be cleavage planes. These crystals lay in oblique positions towards each other, and were probably felspathic. Crystals of leucite have been observed partially included in augite :‡ the converse is common enough. Hexagonal crystals of nephelin occur in augite crystals of the usual form, having the faces ∞P∞ dominant, in the nephelin rock of Meiches in Hesse.§ Sandberger‖ has also observed nephelin enclosed in the augite crystals, from the basalt of Neurod in Nassau. Needles of nephelin are found sticking through crystals of augite, in the cellular hollows of sanidin blocks of the Aschberg in the Rhön mountains.¶ Scales of white talc occur in elongated actinolite prisms from the Zillerthal.** Scales of brown mica occur in the beautiful green elongated prisms of actinolite, having the faces ∞P. (∞P∞) from the talc slate of Zillerthal, in South Tyrol. Red crystals of garnet often occur in the actinolite of Schneeberg in Saxony, and Sterzing in Tyrol. Seyfert and Söchting have found idocrase in hornblende from Vesuvius. Small crystals of black garnet occur in semi-transparent green crystals of augite, having the form ∞P. ∞P∞ . (∞P∞). P. from Somma.†† Bright reddish-brown crystalline particles of olivin, have been found in a crystal of hornblende, from the basalt of Härtlingen by Sandberger.‡‡ The same observer has described a large augite crystal from the same locality, containing particles of a mineral which appeared to be crysolite in the first stage of decomposition. In the single and twin crystals of augite from Monte Rossi, and Atro del Cavallo, Vesuvius, small oil-green grains of olivine occur. Similar grains are to be found in loose crystals, ejected from the crater of Stromboli. Disthene, or cyanite, is frequently found enclosed in the red amphibol, or Karinthin crystals, which occur with cyanite, garnet, and amphibol, on the Saualpe, in Carinthia.

In a considerable collection of specimens of actinolites, from various localities, especially Irish, I have almost always found minute red garnets. In the fine felted actinolite rocks, they are often so abundant that, in washing the finely ground mineral, the garnets sometimes collect together as if powdered cinnabar were mingled with the mineral. Sections of aluminous hornblende crystals almost always exhibit under the microscope minute veins, and sometimes distinct crystals, having all the appearance of feldspar. I have also found in

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* Blum, *op. cit.*, 44.

† De Vesuvii Montis lavis., Dissert. inaug. Berol, 1859, 13 ; and Zeitschrift, d. deutsch., geolog. Gesellschaft, x. 381.

‡ Ibid. p. 13,

§ Blum, op. cit., 44.

‖ Poggend. Annal., lxxxiii.

¶ Wedding op. cit., p. 12.

** Blum—Die Pseudomorph. d. Mineralreichs. 45.

†† Blum, *op. cit.* 43.

‡‡ Poggend. Ann., lxxxiii. 454.

a number of crystals of augite, similar evidence of some feldspar, and in most basaltic augites, olivine. So far as my investigation has yet gone, the three minerals most frequently found in hornblende and augite crystals are, the feldspars, garnets, and olivine.

The aluminous hornblendes and augites have all crystallized in the midst of a mass of orthoclase or potash feldspar, or of plagioclase or lime feldspars, which are mixtures, in various proportions, of albite and anorthite, or, in certain cases, in the midst of nephelin. Whether the crystals were formed by deposition from water or out of a molten mass, they must have carried down with them traces of the feldspar or other substance, out of which the crystals separated, in the same way that all salts enclose more or less of the impurities which are contained in the solution from which they have separated.

When the foreign substances are in solution, whether in water or in igneous fusion, and that the circumstances are favourable for the slow formation of crystals, crystalline endomorphs are formed. If, on the other hand, the hornblende or augite crystals form in a felspathic mass, which is not in a condition to crystallize apart at the moment of the separation of the meta-silicates, the latter, in the act of crystallizing, impose their crystallizing action on some of the feldspar, giving rise to hornblende or augite crystals, containing molecules of feldspar, regularly associated with the meta-silicates in the crystallographic constituent molecules, but not chemically combined with them. The amount of such heteromorphic chemical molecules which can become associated in a crystalline molecule is limited, but variable, to a slight extent, according to temperature, form of the crystals, relations between the crystalline series of the crystallizing body, and of the heteromorphic compound, &c. These circumstances account at once for the apparent definiteness of composition of many aluminous hornblendes and augites, and for the slight variation which is often noticeable in the amount of alumina in crystals from the same locality.

When hornblende and augite crystals are formed in the midst of a very complex mass, the crystallographic molecules may contain two or more kinds of heteromorphic chemical molecules. Generally, however, a feldspar, either of the orthoclase group or of the plagioclase group, is the only, or the principal, heteromorphic chemical molecule present in the constituent crystalline molecule of the augite and hornblende crystals. In some instances, a silicate of the composition of garnet is also present in hornblende, and of olivine in augites; and in those cases, crystals containing these minerals as endomorphs, are often found in the locality. I have frequently found in basic highly aluminous hornblendes, in addition to orthoclase, an aluminate of the composition of spinel $Mg''Al'''_2O_4$. Indeed, it is probable that, in all cases where the silica of aluminous hornblende is low, this aluminate is present, although I have not noticed it as a distinct endomorph, nor, so far as I know, has any one else.

Where the foreign ingredients are unequally distributed, or where, though regularly distributed, they are still distinctly recognizable by

the naked eye, or by the aid of the microscope, they must have pre-existed in the solid form, and been enclosed while in a state of suspension. Of the latter kind are the rhombohedrons of calcite, containing a large quantity of sand, found at Fontainbleau; and the prisms of quartz rock, which consist of quartz sand cemented by orthoclase, meta-silicate of zinc and quartz enclosing silicate of iron, calcite, and chalybite enclosing clay, &c. Many dark-coloured hornblendes contain amorphous endomorphs, which look like enclosed suspended matter; but we have no means of determining its character. It is probable, however, that, in some instances, at least, it is a silicate of iron, for we find some of them associated with crystals of Lievrite.

In conclusion, I think that the opinion of Kenngott and Frankenheim, that the alumina of aluminous hornblendes and augites is present as an impurity, is true; and further, that it is not present in the form of one or more specific silicates peculiar to them, but chiefly as a felspathic mineral, and derived from the aqueous or igneous mass out of which they have crystallized. Again, that, sometimes, in addition to a feldspar, garnet, olivine, &c., some of the alumina is often present as an aluminate—chiefly as aluminate of magnesium or spinel. And, lastly, that the endomorphs and paragenitic minerals are indications of the heteromorphic chemical molecules which most likely enter into the composition of the constituent crystalline molecules, of all varieties, which deviate from the normal types of a group.

XI.—On a New Theory of Nervous Action as regards the Transmission of Sensation along the Nerves. By Robert M'Donnell, M. D., F. R. S. [Abstract.]

[Read May 23, 1870.]

A large number of facts have of late years been observed, tending to show that what has hitherto been regarded as the sense of touch is capable of being resolved into a number of comparatively elementary sensations, as those of temperature, contact, tickling, pain, &c.

Many cases have likewise been observed in which some of these sensations are felt, while others cease to be perceived by the patient. Thus the individual may feel perfectly the contact of the hand, when lightly rubbed over the surface, yet not be able to distinguish heat from cold, or *vice versâ*.

Analogous phenomena are observed with regard to the other senses, as in cases of colour blindness, absence of ear, or inability to hear particular notes, &c.

In explanation of these and other kindred phenomena, it has been supposed that there exist in every nerve groups of distinct conductors, each adapted to convey along it distinct nervous impressions.

This hypothesis is indeed that which is at the present time adopted

by physiologists, and it numbers among its supporters the most distinguished philosophers.

Dr. Brown-Sequard conceives "that he has ascertained that, beside the four distinct kinds of nerve fibres of the higher senses, there are at least eleven kinds of nerve fibres in the spinal cord, and in the cranial, spinal, and sympathetic nerves."

He enumerates these eleven kinds as follows :—

1st. Conductors of impressions of touch.
2nd. " " of tickling.
3d. " " of pain.
4th. " " of temperature.
5th. " " of muscular contraction.
6th. Incito-motor conductors.
7th. Incito-nutritive and secretory conductors.
8th. Voluntary motor conductors.
9th. Involuntary motor conductors.
10th. Vaso-motor conductors.
11th. Nutritive and secretory conductors.

"I hardly need say," he adds, "that the number of functionally distinct nerve fibres is probably much greater than is shown in this table."

As regards the physiology of sensations of colour, a theory so closely analogous as indeed to be identical with reference to the sense of vision was put forward by Thomas Young, at the commencement of this century. He supposed three sorts of conductors to exist in the optic nerve, each specially charged with the function of conducting a different colour, red, green, and violet. The mixture of these three colours in different proportions gave rise to all the other colours of the spectrum.

This hypothesis of Young has, with some modifications as to the colours, found a zealous advocate in the distinguished Professor Helmholtz.

It is not necessary for my purpose to enumerate the various theories which have been advanced in explanation of the various phenomena to which I have just alluded. Suffice it to say that I have long felt that the ingenious idea of distinct conductors did not exactly meet the case. So long ago as in 1861, in a critique on Dr. Brown-Sequard's work in which his theory was first put forward, I expressed the opinion that we could hardly accept the idea "that the nerve fibres employed in the transmission of sensitive impressions of *touch*, *tickling*, *pain*, &c., are as distinct one from the other as they all are, from the nerve fibres employed in the transmissions of the orders of the will to the muscles."

The theory which I venture to propose, and which I put forward with diffidence when I consider that another has been advocated by such able physiologists as Helmholtz and Brown-Sequard, is simply an application of the theory of wave propagation to the passage of various sensations along nerve conductors.

I conceive that the various peripheral expansions of sensitive nerves

take up undulations or vibrations, and convert them into waves capable of being propagated along nervous tissue (neuricity, as it has been named). Thus, the same nerve tubule may be able to transmit along it vibrations differing in character, and hence, giving rise to different sensations; and, consequently, the same nerve tubule may, in its normal condition, transmit the wave which produces the idea of simple contact, or that which produces the idea of heat—or, again, the same nerve tubules in the optic nerve which propagate the undulations of red may also propagate, in normal vision, those which excite the idea of yellow or blue, and so for other senses.

I advocate this undulatory theory of sensation in preference to the theory of distinct conductors—

1stly. Because it is simple.

2ndly. Because it is strongly supported by analogy, when compared with wave propagations in other departments of science.

3rdly. Because it appears to be in harmony with a large number of recognized physiological facts, which seem inexplicable upon the theory of distinct conductors.

It would be obviously impossible, within the limits of one communication, to discuss such a theory in its application to the various senses. I wish merely to bring before the Academy, at present, a general statement of the grounds upon which this hypothesis rests; and I shall hope, hereafter, in several communications, to elucidate its applicability to the transmission of the sensations peculiar to each special sense.

1st. When compared with the theory of distinct conductors, the undulatory theory is obviously simpler as regards anatomical detail. Anatomy has not given any evidence that with an ordinary compound nerve there exist different kinds of conductors—to the highest powers of the microscope all such tubules are identical in appearance. Nay more, we now know that nerves may be so spliced (if I may use the expression) on to one another, that sensitive nerves may be made continuous with those which convey the commands of the will to muscles.

As regards the analogy between this theory of nerve action and the wave theory of light, I do not pretend to say that it holds in every respect: there are obvious points of difference. If we infer that light and heat do not consist of particles emitted by a hot body, our natural alternative is to suppose that they are undulations of a medium pervading space. This hypothesis furnishes by far the best explanation of many very curious phenomena in light and heat, and is now generally received. This medium, which we suppose to pervade space likewise, with more or less freedom, pervades transparent and diathermanous bodies; but nerve tissue being neither transparent nor diathermanous, it is not to be conceived that the undulations of this medium are transmitted along nerve tissue, as if through glass or rock salt: on the contrary, the vibrations of light and heat are transferred from the medium in question to the axis cylinder of the nerve tubule in a form capable of being propagated to the sensorium.

As I conceive, the analogy lies chiefly in this:—as we know, various solid and liquid bodies exercise a selective absorption both for heat and light, in virtue of which certain rays are set apart to be stopped, while certain others are allowed to proceed; after an analogous fashion, certain nerves exercise a so-called selective power, permitting certain undulations to proceed, while those of a different wave length are intercepted. Most substances, including those that are transparent for light, are generally opaque for dark heat of great wave length and small refrangibility. So we have no reason to think that heat can excite in the retina undulations capable of being propagated by the optic nerve to the sensorium, although light certainly does so.

Instead of supposing, like Dr. Brown-Sequard, that there exist a great number of distinct conductors, I should suppose that there are a great number of distinct sensations propagated along the nerve tubules, in undulations of different wave lengths.

As the rays of the heat, light, and actinic spectra differ in refrangibility, so do the undulations produced by heat, cold, pain, tickling, or the unfelt sensations (if I may use the phrase),—which last correspond to the invisible and cold actinic rays.

As in the economy of nature the actinic rays play a part of vast importance, so these vibrations, which play along our nerves, without our knowing it, are all important in the animal economy.

The unfelt tickling, which keeps the heart in regular and ceaseless action during life, is not less important to man than that part of the sunbeam which we cannot see, nor yet feel the warmth of, is in the economy of nature.

Many phenomena such as those connected with seeing complementary colours, when a white surface is gazed at, after the eyes have been fixed upon a blue, red, or yellow disc; the phenomena, connected with peculiar colour, seen after the administration of santonine; the effects of lead poisoning upon sensation, &c., &c., are more easily explicable upon the undulatory than upon any other hypothesis of sensation.

The author concluded by referring to the well-known experiments of Professor Tyndall, showing the power of absorption of vapours and scents, of which minute quantities are introduced into dry air filling a glass tube. In these experiments a physical change of almost inconceivable subtlety is followed by the interception of waves of radiant heat. So with a nerve tubule—a minute quantity, suppose, of santonine, entering into the axis cylinder of the optic nerve tubules (as the scent in the air filling the glass tube), intercepts some light waves of a certain refrangibility; and the result is, that all objects looked upon have their natural colour, *minus* the intercepted undulations. This analogy serves to explain the general bearing of this hypothesis.

XII.—NOTICE OF THE CAPTURE OF ZIPHIUS SOWERBYI. By WILLIAM ANDREWS, ESQ.

[Read June 27, 1870.]

ON the 8th of April, 1867, I had the honour of submitting to the Academy a notice of the capture in 1864 of the very rare Cetacean, "Ziphius Sowerbyi"—the first ever recorded as occurring on the Irish coast: one only having been previously obtained on the coasts of the British Isles. I mentioned that the first specimen whose capture was recorded was taken in Elginshire, in the year 1800, and was then noticed as new to science, having been named by Sowerby, to whom the head and drawings of the animal were sent, as Physeter bidens, from the characteristic featüre of possessing only two teeth, one on each side of the lower jaw.

This remarkable animal, to which Cuvier gave the generic name Ziphius, considering it to be a relic of the past creation, had hitherto been only found in the fossil state. It was not until de Blainville saw, in the Museum at Oxford, the head and jaws of that taken on the coast of Elginshire, that it was detected to be also a recent genus.

I have now the pleasure of recording the capture of another specimen, in the same bay, Brandon, coast of Kerry, and nearly opposite to the shore where the previous specimen was taken in 1864. It was stranded near Corrignakilla Rock (Rock of the Church), in Brandon Bay, on the 31st of May last, but unfortunately was much mutilated by the fishermen, who considered it to be a porpoise, before I received intimation of the circumstance. Through the kind attention of my friend, Dr. Busteed, of Castlegregory, the upper and lower jaws, with the teeth perfect, back portions of the head—the vertebræ, sternum, scapulæ, and pectoral fins have been secured, and portions of the dorsal fin correctly traced.

The capture of so rare a Cetacean, a second time in the same bay, is most remarkable, and being both males, it is not improbable that the females may be on the same coast. I have, therefore, given directions that early intelligence should be sent to me, in the event of another being stranded.

This second occurrence, on the coast of Ireland, is a most remarkable feature in zoological discovery; yet I feel disposed to think that others may have been similarly cast ashore, and have been lost to science, from the want of knowledge of those who have met such castaways.

The animal was supposed to be seventeen feet in length.

XIII.—Address delivered before the Royal Irish Academy. By John H. Jellett, B. D., President.

[Read November 30, 1870.]

It is, as you are aware, the custom that once, during his tenure of office, the President should lay before you a statement of the condition and prospects of the Academy, endeavouring to mark the progress which she has made in the several parts of her varied programme, and, should there appear in any part of our field of labour a movement other than that of progress, directing there your most earnest attention, with a view to arrest and remedy the evil. It is a custom not rendered in any wise superfluous by the Reports which, from year to year, are presented to you by the Council—valuable, nay, absolutely necessary, as these Reports are. For the function which they have to discharge is different in at least one important respect. The purpose, which the Council in its Annual Report seeks to fulfil, is, to note the changes which have occurred during the preceding year, in order that immediate attention may be given to any part of our system seeming to require it. But it is not possible to form an adequate idea of the progress or decay of any great institution from observations extending over so short a time. The changes there noted may be, to speak mathematically, changes of short period, phenomena arising from some accidental cause, which the succeeding year may arrest or reverse, and therefore not affording a true indication of the real progress of the institution. Thus, for example, even the number of communications read before the Academy, the most significant mark of intellectual life, is, when examined and compared for a period so short as a single year, in some respects a fallacious test. If indeed the number of such communications in any given year were a truthful measure of the intellectual activity of our members during that year, we might, with a certain amount of probability, infer from it the growth or decay of the institution. But this is not so. Intellectual *activity* we can in general command. If an institution like ours be prosperous, intellectual activity should be persistent or progressive. But intellectual *success*, that which is really indicated by a communication to the Academy, is far more capricious. We cannot command it. We cannot predict it. Discovery follows no law which we can ascertain. Intellectual activity is its *condition;* but within a period so short as a year intellectual activity cannot ensure it. The chance is indeed only for the good player, yet even for him it *is* a chance.

I am addressing those who know how true this is—who have learned by bitter experience how the labour of weeks and months may pass and leave no sign—how one small fact, the observation of an hour, has shown that the path which they followed is barred, forcing them to confess that the way of nature was not as they thought it to be, forcing them to confess that their toil has gone to that which profited

not, to fling aside results so laboriously and painfully obtained, and with a saddened heart to commence their work again. But I shall have occasion to allude to this topic further on, and I touch upon it now only for the purpose of showing that in a society like ours, where the number of labourers in each department is not very great, the records of a single year are a wholly unreliable test of the intellectual activity of our members. This unavoidable defect may be supplied by the address of the President. The review of the progress of the Academy which he brings before you should be founded on an induction sufficiently large to eliminate accidental disturbances, thus enabling you to judge, with at least a high degree of probability, whether the institution be really advancing or retrograding.

I would observe here, also, that in order to estimate rightly the condition of an institution like this, we must look beyond the institution itself. Without such an examination we may commit the serious mistake of attributing to our own merit or default that which is really due to the general condition of some one branch of science. For progress in each department is not, any more than success in individual labours, uniform or even constant. In every such department there are periods of rapid advance and periods almost of stagnation—times when discoveries crowd upon us with a rapidity which is absolutely dazzling, and times when it might seem that the mine had been worked out. And therefore if we do not look beyond ourselves and our own labours, we may attribute that to our own culpable inactivity, which is really due to a general stagnation in some department of science. Or, on the other hand, we may take credit to ourselves for successful labour, when we are but sharing, and that imperfectly, in the general advance—swept onward by a stream which is really passing us by.

I take an example from our own history. We all know—many of us remember—how our meetings and our published records were adorned by the magnificent speculations of Professor M'Cullagh upon Physical Optics. Subsequent research has indeed shown that neither these nor any similar speculations faithfully represent Nature; but no subsequent research can displace them from the position which they hold, as a combination, rarely surpassed, of mathematical and physical genius. But would it be reasonable that we should feel disappointment because we have nothing like them now? I think not. For those were the days of Cauchy, and Neumann, and Green, and others, all intent upon the same problem—days, when the attention of the scientific world was largely given to the attempt to construct mechanical theories which might explain (in the popular sense of the word) the phenomena of light. But it is not so now. The study of Physical Optics has not ceased. On the contrary, I have but to pronounce the word "spectroscope" to show that this study has become more active than ever. But it has taken a different direction; more experimental, less theoretical. Mechanical theories of light have, if I may so express myself, gone out of fashion, and it would be unreasonable to expect *here* an activity which, in this direction, has everywhere slackened.

Having premised so much for the purpose of showing that, if we would estimate rightly our progress in any branch of our study, we must not only look back over a considerable period of our history, but also beyond our own institution to the general history of scientific progress, I would now proceed to examine more particularly the several departments into which the Academy may be divided. Let me commence by saying a few words of two departments of the Academy which are necessarily progressive, at least in a certain sense of that word. We are constantly adding archæological curiosities to our Museum—books and manuscripts to our Library. Are we adding as much as we might? Are we using them as we ought? And first, as to our Museum.

It is, I fear, but too certain that every year witnesses, in Ireland, the destruction of objects of great archæological interest. More especially, objects in metal, gold and silver ornaments, are bought up from the finder by travelling hawkers, are sold by them to the silversmith, and so find their way to the melting pot. And thus many most interesting relics of the olden time of Ireland have perished. The most strenuous efforts have been made, more especially by our late President, to arrest this evil. The Crown was induced to waive its rights of property in our favour. Parliament gives us an annual grant for the purchase of these articles, and we are always ready to buy them at their full intrinsic value. Yet from some unaccountable fatuity, the finder, instead of sending them here, will often rather dispose of them to a hawker, at a price, it is believed, very far below that which he might have obtained from us. In this state of things, only one remedy seems to be within our power, namely, the widest possible publication of the fact, that the Royal Irish Academy *is* ready to purchase at their full value objects of antiquarian interest. This publication we have endeavoured to effect by dispersing through the country notices, illustrated by woodcuts of the principal types of such objects, and giving full information to the finder as to the highest, and safest, market for them. These descriptive notices have been, and are being, hung up in all the National schools, and it is hoped that the effect may be found beneficial.

But we have another class of rivals for the possession of such objects. I mean, the private collectors. These are not, indeed, so injurious to the cause of Archæology as the silversmiths. They do not destroy the objects—nay, they often do good service by preserving them. But I must add, they often render them useless—in fact, as far as the general student is concerned, they must be useless. No man will, or indeed can, make his house generally accessible for purposes of study. And so, in truth, the difference between the fate of the antiquarian relic which finds its way to the melting pot, and the fate of that which is entombed in the cabinet of a private collector, is often only the difference between the fates of money thrown into the sea, and money buried in the garden. The first is lost for ever. We may hope that, at some future time, the second will turn up; but for the present

they are equally useless. I do not, of course, speak of all private collectors. A museum, in the hands of a Petrie, may be of the highest utility. But I do say without hesitation that an antiquarian museum, in the hands of a man who is not an archæologist, is like a library in the hands of a man who cannot read. Let me ask, what should we think of his patriotism, who should occupy himself in purchasing and locking up unique works having an important bearing on the history of this country, unable to read them, and only delighting himself in contemplating the bindings?

Yet this is precisely what the non-archæological collector does. For I cannot too frequently remind you that an antiquarian museum is not meant to be a collection of pretty baubles to look at. It is the library of the ethnologist—a collection of documents in which we read the description of a former race—of materials from which the history of a country must be written. And he is no true antiquarian, not even in spirit, who regards such a collection with a kind of miserly love—very anxious to preserve it, not at all anxious to use it—perhaps unable to use it—exerting himself, not to the benefit but to the injury of Archæology, by hindering such articles from falling into hands, in which they might be made useful to mankind.

Such a spirit might even creep in among the guardians of a National Museum. I hope and believe that it will never be found among us. For, bad anywhere, it would be wholly unpardonable here. We hold our archæological treasures, not as owners, but in trust for Archæology—in trust, not to hoard them unseen, but to use them, and to allow others to use them, for the benefit of archæological science. And by whatever path we can best attain that end—by freely opening our Museum to the public—by multiplying and disseminating photographs and casts and models, or even, if need be, by lending them under proper security for exhibition—by that path we are bound to walk. I believe that we are all actuated by this spirit; and as one indication of its existence, I ask your attention to the beautiful series of photographs of the principal articles in our Museum, which have been executed, and will shortly be published.

We are not without hopes of adding to our collection two objects of the highest interest, but which, principally from want of funds, we have as yet been unable to secure.

The Ardagh Cup, a beautiful sacramental chalice, dating probably not later than the tenth century, has been deposited in our Museum by the Earl of Dunraven, to whom it has been intrusted by the proprietors.

It is an exquisite specimen of the best period of Irish art, and is further remarkable as being, with I believe one exception, the only instance discovered in these islands of the double-handled sacramental chalice. It is earnestly to be hoped that this beautiful cup may not be lost to the student of Irish Archæology, but that the Museum of the Royal Irish Academy may be its final, as it is its most suitable, resting place.

Less beautiful as a work of art, yet having the advantage of a well-marked history, is the bell-shrine of St. Patrick, enclosing the old iron bell supposed to have belonged to the patron saint of Ireland, and of which a record exists dating as far back as the sixth century. The shrine, which is a jewelled case intended for the preservation of the bell, appears to have been made at the end of the eleventh or beginning of the twelfth century. These interesting relics are the property of Charles Todd, Esq., who has offered to dispose of them to the Academy. It is to be hoped that we may be able to secure them.

Two features connected with our Library deserve your attention.

The first of these concerns our collection of the Transactions of other learned societies. It is, as you know, one of the most important functions of a public library that it should possess a collection, as complete as possible, of books which, though of the highest value to the student, are, from their great size and cost, seldom found in private libraries. Conspicuous among such works are the Transactions of learned societies. We have therefore for some time past been endeavouring to form, principally by exchange, a collection of past and contemporary publications of the chief bodies throughout the world engaged in scientific, literary, and archæological investigations. In this we have succeeded to a very considerable extent, and already a large number of such publications are, soon after their issue, available to readers here.

The other point connected with our Library, which I wish to notice, concerns our collection of Irish manuscripts. The library of the Royal Irish Academy possesses, as you are probably aware, some of the oldest extant manuscripts in the Irish language. These manuscripts, which are necessarily of great philological importance, we are anxious to make available to the student of the Celtic languages, not only here but at a distance. We have therefore undertaken the printing of accurate lithographic copies of the chief of our MSS.—a task which has been completed in the case of the Leabhar na h-uidhre, the oldest non-ecclesiastical Irish manuscript now in existence. A lithographic fac-simile of this important manuscript now lies on the table. I may mention, as a proof of the interest excited by this publication among scholars resident at a distance, that our distinguished countryman, Mr. Whitley Stokes, has, from this lithographic copy, completed an edition of one of the fragments contained in the Leabhar na h-uidhre, the contractions appearing in the original text being replaced by the letters in full, and the whole being accompanied by a translation, of the accuracy of which the well-known philological skill of the editor is a sufficient guarantee.

I now come to speak of that which is the true indication of intellectual life in such a society as this. I mean the Papers read before the Academy, and printed in our Transactions and Proceedings. We must not disguise from ourselves the truth, that, however we may succeed in the other departments of which I have spoken—in accumulating an admirable Library—in storing our Museum with archæological treasures—if we fail *here*, we fail in our most important func-

tion. Nay, I will go farther and say—if we fail here, we fail in the end to which the others are but means. What avails it that we have arsenals stored with the choicest weapons, if our arms be too indolent or too weak to wield them? What avails it that we have a Library replete with books, which should aid us in investigating the truths of science or of criticism; or a Museum rich in the materials by which the history of our country is to be written, if, through our inactivity, the mines of literature or science be unworked, at least by us, and our Museum fulfil no higher function than that of a collection of pretty curiosities to amuse an idle hour? I am far from saying that the labour expended on these collections is, even then, useless. But if you should be disposed to look on such a state of things with self-complacency, remember that, although we have done well in accumulating materials, which a stronger generation may use, it is not the less a reproach to us that *we* have failed to use them. Do we merit that reproach now? We must not shrink from the question.

What answer can we give to that question in the department of Science? Does our history for the last five years show progressive or even sustained activity? I cannot say that the answer is satisfactory. The number of scientific communications made to the Academy during that period does show a diminution sufficiently marked to attract our most earnest attention. This diminution we must try to arrest; and that we may do so effectually, let us, in the first place, seek to interpret it, by examining successively the several great divisions of science, and comparing the progress which they have made in our hands with their advance in the scientific world generally.

And first, with regard to Pure Mathematics. Here the diminution during the last five years is very marked indeed, even as compared with the preceding five years, and still more as compared with the ten years from 1850 to 1860. But it is necessary to observe that there are circumstances connected with Pure Mathematics which render a diminution of activity *here* less significant than it would be in other branches of science. In the first place, the progress of the science itself is not as rapid at present as it has been in other periods of scientific history. This slackening is particularly apparent in a branch of Pure Mathematics which was, at one time, a highly-favoured subject with Irish mathematicians—I mean the geometry of surfaces. The impulse given to this study by the discoveries of Chasles appears to have much abated, and this abatement has probably operated largely in producing an effect which is greatly to be deplored—namely, that, with some honourable exceptions, the younger Irish mathematicians have not contributed to the Irish Mathematical School all that they might have given. But, passing by this consideration, I would remind you that we are not the only society which has to remark upon a diminution in the number of communications in Pure Mathematics. Compare, for example, the number of such communications read before the Royal Society during

the last five years, with the corresponding number for the five years immediately preceding, and you will find the same phenomenon.

Again, there is another cause, which has always rendered the number of Papers on Pure Mathematics very uncertain—namely, the small number of labourers employed in that field. Not now, for the first time, have we to remark upon the paucity of such communications. If you examine the records of the Academy for the years 1836 to 1840, you will find that Pure Mathematics had well nigh disappeared. And yet those were the days of Hamilton and M'Cullagh. Again, if you examine our records for the period during which these communications were most numerous—the decade, namely, 1850–60—you will find how largely we were then indebted to the illustrious mathematician just mentioned, and to our former President, the present Bishop of Limerick. Nor are we singular in the smallness of our purely Mathematical School. The records of the Royal Society have a story to tell which is very similar. I may mention as a remarkable fact, that their Proceedings for the Session, 1868–69, contain but three Papers in Pure Mathematics, all of which come from the same author, Professor Cayley.

The truth is, that the brilliancy which of late years has marked the track of experimental discovery—the more striking, popular, may I add, intelligible, character of the truths of experimental science—has proved too powerful an attraction. The splendour of these discoveries appeals to the imagination of the younger student with a force which is wholly beyond the reach of Pure Mathematics. And the mathematician must be, as a student, absolutely unselfish. Every motive to exertion—the hope which brightens the commencement of his toil—the reward which crowns its close—must be found in the study itself. All the external incentives to labour—the wonder with which the outer world follows the path of the astronomer—the vigorous, noisy, almost polemical, energy, which attends the speculations of the geologist—these are not for him. He may be enthusiastic in his pursuit; but his enthusiasm will wear, in the eyes of the outer world, somewhat of a grotesque aspect. They can understand and sympathize with the ardour of other scientific men—the passionate longing with which the astronomer strives to penetrate the secrets of the vast abyss—with which the geologist seeks to unrol (if I may call them so) Nature's autobiographic records; but who, say they, could grow enthusiastic over a differential equation? And when we reflect how earnestly we all desire the sympathy and admiration of our fellowmen, can we wonder that few are found to devote their lives to a pursuit so essentially lonely? Is it not rather wonderful that there are so many?

And if the mathematician works unsympathized with, he works too unaided. All those external appliances, essential to the experimental philosopher—which a society like ours can, and does supply—he does not need. All that we can do for the mathematician is, to listen with respectful attention to any communication which he makes to us,

and to ensure to his discourses a ready and speedy publication. This, I may surely promise, the Royal Irish Academy will be always glad and proud to do.

Turning now from Pure to Applied Mathematics, I may repeat something which I have before said. I may repeat (I am sorry to say) that here, as in Pure Mathematics, the history of the Academy for some time past does not show that intellectual activity which we could wish to see. Part of this effect is probably due to a cause which I have noticed before—general decline of scientific interest in a subject which once occupied much of our attention here, namely, Molecular Mechanics, passing into Mathematico-Physical Optics. But after all due allowance for the operation of this cause, enough remains to cause us serious anxiety, lest, by neglect of ours, we should lose any opportunity of rendering to science a service which only a scientific *society* can render. For our function here is of much greater importance than in the case of Pure Mathematics. With the mathematician it is comparatively unimportant whether his discoveries be given to the world through the medium of a scientific society, or through the medium of a separate treatise. But with the mathematical physicist it is far from being unimportant. He is not—ought not to be at least—a solitary student. If he would have his theories to be something more than mere mathematical speculations—if he would acquire for them the character of true, or even approximate, representations of Nature—he must come among other scientific men, who are viewing the subject from a stand-point different from his own. He must correct his speculations by the practical knowledge of the experimentalist, content to modify every favourite theory to meet the hard requirements of reality—nay more, content, if need be, to surrender it altogether—to hear and obey the voice of Nature, which tells him that he is pursuing an unreal phantom, sure to elude his grasp—which tells him that if he be indeed a worshipper of truth, he must give diligent heed that no symmetric beauty of the theory hide from him the one great question, Is it true. And there is nothing which will more effectually correct the habit, so injurious to the progress of physical science, of adopting physical theories solely on account of their mathematical beauty, than free discussion of such theories by an experimentalist, with whom mathematical beauty counts for very little, and whose sole object is to inquire whether the theory presented to him be a faithful representation of nature. Did we value such discussions solely in their character of destructive criticism, we could, even then, scarcely value them too highly for the service which they can render to the mathematical physicist, by constantly reminding him that *he* has to deal with realities, not mere abstractions, however beautiful, and thus saving him from the expenditure of time, and labour, and genius, upon that which is—physically—unprofitable.

But this is not the only service which the experimental philosopher can render to the mathematical physicist. He can suggest as well as correct. If he can check the growth of weeds, he can also save the

soil from remaining barren. The most fertile, because the truest, inspiration which can fill the mind of the mathematical physicist comes from the facts which experiment has collected. And here I would remind you that the benefit is fully reciprocated. Each can do for the other that which he cannot successfully do for himself. If the experimentalist recals the mathematician from the world of abstraction to the world of reality, the mathematician in turn can give to the observations of the experimentalist a coherence and a significance which he himself might have been unable to perceive. Analogies which he might never have observed—generalizations to which he might never have attained—may become at once apparent to that power of theoretic combination which his habits of thought have given to the mathematical physicist.

The practical conclusion with regard to our studies here, and the mode of pursuing them, is not far to seek; but as it is a conclusion applicable to every part of our programme, and not only to those which we have been considering, I shall defer anything which I have to say on this branch of my subject till I have completed the survey of our progress in other parts of the field of Science.

But, in passing from the subject of Applied Mathematics, I would express my earnest hope, that in the Irish Scientific School, the study of this great branch of Science may never be allowed to languish. It is here that the scientific historian has to record the noblest efforts of scientific genius. It is this which has given to us the "Principia," the "Mécanique Analytique," the "Mécanique Celeste," works of which we may almost say that they are immortal as Science herself. And if we may be allowed to turn our gaze forward—if we may seek to penetrate the darkness which hangs over a region so vast as the future of Science—we may say that in Applied Mathematics we look on the future monarch of the scientific world. That day is indeed far distant, and any attempt to precipitate its coming can but postpone it. Yet who can fail to see that the relation of Applied Mathematics to the domain of Science is one of unvarying conquest. Astronomy and Mechanics have long since yielded. Heat, Light, Sound, Electricity, Magnetism, are all but subdued; and if Chemistry, with her vast and varied phenomena, still holds out, there are not wanting symptoms which allow us to hope that for her too the day will come, when she shall fully vindicate her claim to the title of an exact science, by acknowledging the same authority.

The contemplation of that vast though shadowy prospect, has in it a power which some would deny to Science. It can attract the imagination no less than the reason. Yet if we would show that the science which we have been considering does indeed possess that power, we need not look to the future. The records of the past bear testimony to the same thing. Need I remind you of the great effort of scientific genius which our own time has witnessed—I mean the discovery of Neptune. Need I remind you that it was no astronomical observer, no practical skill, which gave to us that great discovery.

We owe it, not to the telescope of the astronomer, but to the pen of the mathematician. And surely it would be hard to find in the history of the human intellect anything more irresistibly attractive to the imagination—more poetic (if I may use the word)—than the thought that on that scribbled page, in those grotesque symbols, lay a power which enabled the mathematician to look up from his table in the solitude of his own study—to point to the heavens with the unerring finger of Science, and to say—I cannot see it, but it is there.

I have already, in treating of Applied Mathematics, spoken at some length, incidentally, of that branch of Science, which we commonly call Experimental Physics, and which I might indicate geographically by saying, that it is bounded by Applied Mathematics on the one side, and by Chemistry on the other. But neither of the boundaries is a very sharp one; and of the second, more especially, I may say, that the constant tendency of Science is to obliterate it. There are, indeed (to continue the geographical form of expression), large tracts of either territory in which the right of property is clear enough. But there is also on the frontier a great and increasing region, where the two districts overlap—to which neither has an exclusive title, but which may truly be said to belong to both. And the history of modern Science shows every day more clearly that this "border land" is peculiarly fruitful in discovery. This alone would sufficiently justify the mode in which I wish to treat this part of my subject. But there is another reason, which even more concerns my present audience—namely, that this region may be most advantageously worked by a mixed society like ours. I am very far indeed from undervaluing societies specially devoted to the study of Chemistry. They have their function to discharge; and an important function it is. But I think we may say, that their proper sphere is to be found, rather in those problems which can be solved by the powers of Chemistry alone, than in those which will yield only to an alliance of Chemistry with some other science. Now such an alliance may fitly find a place in the Royal Irish Academy. We who are limited to no one science—who number among our members labourers in every part of the scientific field, may profitably attempt the solution of problems requiring the force of more than a single science, and therefore not coming so properly within the scope of a society whose field of labour is more limited.

Applying this principle to our present subject, I would indicate, as an alliance which has already been very fertile—an alliance whose powers, far from being exhausted, are but now beginning to make themselves known—the combination of Optics and Chemistry. What it has effected already—how the science of Optics has reacted upon Chemistry, endowing it with an analysis, refined and powerful beyond any which it has hitherto possessed—giving it to know of new elements which, unaided, it might never have discovered—how both these sciences combined have reacted upon Astronomy, placing, we may truly say, the immeasurably distant star in the laboratory of the chemist, and enabling him to detect in its atmosphere the presence of nitrogen

or sodium as surely as if he held the assay in his hand—all this the history of the spectroscope has told us. But the spectroscope does not furnish us with the only point of contact between the domains of Optics and Chemistry, and indeed this part of the field is at present so thronged with labourers, that it may well be our wisdom to look for ground less occupied. Such ground, common to the two sciences, giving large promise of fertility, and at present most inadequately worked, I believe that we have in the phenomena of polarized light. It would be impossible, within the necessary limits of an address, to give you all the reasons for this belief. Let it suffice to remind you, as an instance of the power of such an alliance, that not long since there was read before us here, by our eminent fellow-academician, Dr. Apjohn, the result of an analysis, which was beyond the powers of Chemistry alone, and beyond the powers of Optics alone, but which was effected, successfully and easily, by a combination of the two sciences.

I would earnestly press upon chemists and physicists the importance of this refined and powerful instrument of analysis. I cannot promise you that its use will be unattended by difficulty—what great purpose is? On the contrary, my own experience bids me warn you that these difficulties are many and great. But I do say that in the phenomena of polarized light, Organic Chemistry possesses an instrument which she will do well to utilize—an instrument laying open to her a field of discovery whose limits it is not easy to see.

And, addressing myself more especially to the physicists and chemists of the Academy, I would say: For slackness in these departments—and till the last year we have been slack—the state of the scientific world affords us no apology. Never were the sciences of experiment more active than they are at present. In Chemistry alone, and before the Royal Society alone, the number of communications has for the last ten years averaged more than twenty in the year. I am sure that I express the feelings of every member of this Academy when I say, we must not allow the present state of things to continue. We must not allow the reproach to attach itself to Irish science, that while the rest of the scientific world is advancing with rapid strides, we, the principal scientific society of Ireland, are alone holding back.

I have dwelt at great, perhaps disproportioned, length, upon the state of the Academy with regard to the sciences of demonstration and the sciences of experiment, principally because our history seems to show that it is here we should bestow our most heedful attention, lest we fail in the duty which we owe to science. I must now pass rapidly over the remaining part of my task.

With regard to those sciences which may be called with sufficient accuracy the sciences of observation, as distinguished from the sciences of experiment—Geology, Zoology, Botany, and Physiology—it must be remarked that our success or failure is not, here, as significant as in some other instances. We are not, here, the sole mouthpiece of Irish science. The Royal Geological Society, the Natural History Society, the Microscopical Society, with the several societies directly connected

with the medical profession, give, as well as we, to Irish men of science a ready method by which they may make their thoughts and discoveries public. Yet, notwithstanding all that has been, in other ways, given to the public, the number of communications actually made to the Academy, on these subjects, cannot be considered unsatisfactory, as compared with that number during former like periods. Microscopical science has found its way amongst us. Zoology, Botany, and Physiology show increased activity, and the researches of Professor Haughton in Animal Mechanics exemplify a principle to which I have before referred, namely, the importance of the results which may be expected from a combination of two sciences.

The same principle, which may indeed be called the life-blood of our system, is exemplified even more strongly by Geology; and we may say, I think, with good reason, that at least some classes of geological questions may be discussed more appropriately in this Academy than in any other society. For Geology is truly the connecting link between the two great divisions under which our studies here may be arranged—Science and Archæology. In *all* its parts it may be called the Archæology of Nature; in some it becomes truly the Archæology of Man. When Geology derives arguments, not merely from the physical formation of the strata, or the animal or vegetable remains which are buried there, but from the existence of implements, having apparently a human origin—when it becomes to her a matter of importance to decide whether a given flint chip owed its form to an accident, or was fashioned by the hand of man, she then enters upon a field which is common to her with the archæologist—upon questions which are most fitly discussed, neither in a purely geological society, nor in a purely archæological society, but in one where both these sciences are represented. And we, gentlemen, are such a society.

Nor is the instance which I have adduced a solitary one. The interesting and important question of crannoges, a question usually and rightly classed under Archæology, could not be discussed without the aid of considerations which are properly geological. Here again a mixed society like ours has an advantage over one which is purely archæological.

The employment of optical science as a handmaid to Physiology is still in its infancy, and it would be difficult indeed, *now*, to predict its future. Yet even the researches which have been already made—the use of the spectroscope—the use of the phenomena of polarization, in questions of Physiology and Pathology—indicate something of the vastness of the field upon which we are entering. It is still indeed dim. We are looking upon it by twilight, but everything indicates that it is the twilight of the morning.

The words Polite Literature, as applied to a division of our studies here, are somewhat deceptive. They indicate (if taken in their ordinary sense) a field of labour very much wider than is consistent with the interpretation which we practically give them. Much that is usually included under those words—fiction, poetry, even criticism—

is practically excluded. Generally speaking, the departments of Polite Literature which find most favour with us are those which border most nearly upon the other branch of our programme—Archæology; and I have no doubt, therefore, that the Academy has done wisely in consolidating these divisions, by embracing in a single department Polite Literature and Antiquities. I have not, I am happy to say, any complaint to make of the inactivity of our members in this department On the contrary, the number of communications upon this subject made to the Academy during the last ten years is considerably in advance of the number of those made during the previous decade.

But the length at which I have spoken on the department of Science, forbids me to enter upon the other great division further than I have already done in speaking of the Museum and the Library. I regret this the less, partly because the amount of good which the President can do by his Address must depend largely upon his own familiarity with the subject upon which he undertakes to speak, and partly because the fact that my three predecessors in this chair have been able archæologists, makes it the less necessary that I should dwell upon the subject now.

Before passing from it, however, I would indicate as an object closely uniting the two parts of this great division—an object, too, in every way worthy of the attention of the Royal Irish Academy—a more profound study of the philology of the Celtic languages. In truth, this is the purpose which our valuable collection of manuscripts is really calculated to serve. It is this, and not mere literary interest, which makes them valuable. The deciphering of inscriptions—a work to which the ingenious method described and practised by Dr. Ferguson promises increased success—should contribute to the same object; and among secondary aids to the same purpose, I may mention that a considerable sum of money has been given by the liberality of Mr. Hudson towards the formation of an Irish dictionary, but has unfortunately now lain for many years idle. The weapons are there; it only wants the arm of an O'Donovan to wield them. If Mr. Whitley Stokes were resident in Ireland, instead of being resident in India, how great would be the benefit to Celtic philology. It seems proper to mention here, although probably many of you know it already, that an attempt is being made, at once to serve the cause of Celtic philology and to perpetuate the name of one who was so long and so intimately associated with the Royal Irish Academy, by the foundation of a Todd Professorship in the Celtic languages. Could a sufficient sum be obtained for this purpose, the best results might be anticipated.

And now, gentlemen, in drawing these remarks towards a close, I would inquire, Does the review in which we have been engaged suggest any practical expedient by which the efficiency of our labours may be increased, and with it the number and value of our contributions to Science and Archæology. Two such suggestions occur to me.

I would earnestly press upon all our members, and more especially upon those who are themselves engaged in scientific or antiquarian

researches, the propriety of a more regular attendance at our evening meetings, We should seriously underrate the benefits which a scientific or archæological society can confer, and, more than that, we should wholly misconceive its most important function, if we regarded it merely as a publishing society—as a machinery for giving to the world, through the agency of the press, the various communications which have been, by their authors, intrusted to it. If this were true, the purpose might be attained as efficiently, and far more simply, by sending the communications to the Secretary. If this were true, then, a scientific society like ours would find it difficult to justify, if not its existence, at least the mode of its existence, with all the costly arrangements for holding its evening meetings, for enabling authors to read their Papers before the assembled society, instead of sending them at once to the press. But it is not true. It is in these Evening Meetings—in the opportunity there given to an author of reading before his brother-members a Paper as yet unpublished—in the discussion which will generally follow—in the questions which may be put to the author—in the suggestions which may be made by other members—it is in all these, and not in the mere publication of the Papers, that we are to look for the great value of a learned society.

I take an example which is familiar to us all. We should seriously underrate the value of the British Association, if we measured that value solely, or even principally, by the annual volume which it produces. And probably many do thus underrate it; but, I think, erroneously. The true service which the British Association renders to science is not measured by its volume of Papers, when published, but by the discussion which these Papers evoke when read—by the concentration, for the time, of many minds upon the same point; and by the suggestive thoughts—suggestive above all to the author of the Paper—which the varied intellects of those who criticize his work, and the different stand-points from which they regard it, may well be expected to produce. Few of us, perhaps, are aware how much we owe to this contact with other minds—how often it happens that a thought which we have afterwards brought to maturity has been, in germ, deposited in our minds by some casual remark made—some simple question put, by another person, whose mind is running in a somewhat different groove.

This consideration is so intimately connected with the utility of our Evening Meetings here, that I venture to exemplify it by an incident which occurred to myself.

Some years ago I described to the Academy an instrument by which the plane of polarization of a polarized ray might be determined with considerable accuracy. The purpose with which I had devised the instrument was purely optical, and at the time I had no thought of any different application of it. But in the discussion which followed my Paper, Dr. Apjohn, whose thoughts naturally turned upon Chemistry, asked me whether my prism could be applied to the saccharometer. At the moment I said, no; giving, I believe, some

reasons for my opinion. But the question rested in my mind, for I saw its importance, and after some thought I was able to perfect the instrument, which I subsequently exhibited and described to the Academy, and which has a certain scientific value. I believe that the experience of scientific men, if consulted, could tell many a similar story.

There is another practical suggestion which I would venture to offer. Why should not combinations of two or more scientific men for a common purpose be more frequent among us than they are? The history of Science is replete with instances in which such combinations have produced the happiest results. Fresnel and Arago, Kirchoff and Bunsen, Huggins and Miller—these are but a few of the instances in which the most important additions to our scientific knowledge have been made by the combined powers of two men. And if you have followed the train of thought through which I have endeavoured to lead you, you will probably have come to the conclusion, that never in the history of Science were such combinations more desirable than they are now. If it be true that no part of the scientific domain is so fertile as that frontier land, lying between two sciences, and which may be fairly said to be the property of both, then it is true that we may expect, from the labours of two men combined, far more than could be produced by the labours of the same men entirely separated. Each man, by his own peculiar training, is able to supply the skill and knowledge which the other lacks, and, therefore, to suggest expedients which might never occur to the other—to remove difficulties which, to the other, might be insurmountable. The method has been successfully tried elsewhere, and before. Why should not we try it here and now?

I have said so much of the advantages which may flow from an alliance between Physics, commonly so called, and Chemistry, that I need not dwell upon it further; but I may observe that a similar alliance between Physics and Biology would go far to remedy the evil, so bitterly complained of by Comte, that the cultivator of biological science is rarely a physicist or a mathematician. Of the advantages to be gained from a combination of these powers and pursuits in a single individual, we have, as you all know, in this Academy, a most remarkable instance. But the history of Science shows us that this union is rare; and although something may be done to promote among the students of Biology a more profound knowledge of mathematical and physical science, I fear that the great labour which such a philosophic system of education would require, combined with the fact that, amongst us, the cultivator of biological science is, in general, also a member of an active profession, will render such a union always rare. And if you cannot have these qualities united in the same man, surely the next best thing is to realize, as far as possible, the advantages of such a combination by the united efforts of two men.

And here I may suitably remind you that the Academy is possessed of a considerable grant for the sole purpose of aiding scientific investi-

gations, and that the Council has always been most liberal in allocating money for the illustration of any important papers which have been entrusted to us.

A word, in conclusion, to the two great classes into which here, as everywhere, men are divided—the labourer and the looker-on. These classes, indeed, necessarily overlap. The earnest labourer in one department will probably be a looker-on in many others; but you will readily understand that the distinction is quite real.

And first I would say a word to the looker-on.

My brother Academician, you will not, I hope and think, fall into the error of supposing that, because in some one or more departments you are not a labourer—because, in those departments, the active work of Science must be done by other hands than yours, you have, therefore, no function to discharge even there. The truth is far otherwise. If you cannot assist in that work directly, yet the indirect aid which you *can* give, sometimes perhaps by criticizing, at all times by stimulating and encouraging—by stimulating the inactive, or encouraging the despondent—is of the highest practical importance. Perhaps, indeed, if human nature were less imperfect than it is, the love of truth alone would be motive sufficient without any such indirect aid. But we must take human nature as it is. We know that this motive is not always sufficient, and we know, too, that among the secondary forces which urge on the student, none is more powerful than the sympathy of his fellow-man. It is that sympathy which I ask you to give—to give, not only to those whose labours may be akin to your own, but to all who are striving, each according to his several ability, to carry forward the sacred banner of Truth. We, gentlemen, members of a society whose pursuits are so various, that they might almost seem unconnected, have more especial need of this catholic sympathy. Let us try to feel and to show it—the archæologist to the man of science; the man of science to the archæologist—driving from our minds all base jealousy of each other—rivals in nothing but in devotion to the one great cause, to which, in different uniforms, and under different leaders, we are all pledged alike.

And, still addressing the looker-on, I would say, do not allow yourself to be too impatient in expecting results—do not be hasty to condemn the labourer, because no fruit of his toil is at once apparent. Remember how small a fragment of his path is visible to you. You see but the successful close. To you it is given to assist at his triumph; but of the path by which he has reached the goal, traversed, not like that of the politician, amid noisy congratulations, but in loneliness and in silence—of that you know nothing. You know not of the obstacles which have crossed that path, or how slow and painful has been their removal: you know not how often he has paused in his course, longing yet dreading to take the next step, lest it should show him an obstacle which he cannot remove—a barrier which he cannot cross; or, worse still, lest that step should reveal the object of his pursuit as an

unsubstantial phantom. You know not—but let your imagination paint for you such a picture, and you will not be impatient.

To those who are themselves engaged in the struggle I would hold a somewhat different language. If it be the duty of the looker-on to aid you with his trust, his sympathy, his applause, it is your duty to see that these indirect assistances be, as far as possible, unnecessary to you. You must hold before your eyes a loftier ideal: your devotion to Truth cannot be too pure from the admixture of any other motive. Above all, you must not be a worshipper of success. That which is unjust in the looker-on would be treason in you. If you would be faithful to the great cause to which you are engaged, you must not require success—at least, that success which can be made apparent to the world—as the necessary price of your labour. For it is a price which Truth cannot undertake to pay. If, indeed, we could assign to each investigator his share in any great discovery—if we accustomed ourselves to remember how one man collected the facts from which the discoverer, as the world calls him, drew the conclusion—how another contributed to it by what the world would call his failures, by following delusive paths far enough to prove that they are delusive—if we accustomed ourselves to do all this, we should probably learn that success, in this sense, is within the reach of all. But we do not judge thus, nor does the world call this success. The garland of victory is destined to him who has overleaped the last barrier and reached the goal; while the man who, by patiently removing obstacles from his path, has rendered the achievement possible, may pass unhonoured, perhaps unknown.

I have said that your devotion to Truth should be, as far as possible, pure from the admixture of other motives. Yet even to that principle there is an exception. There is a thought which may mingle most worthily with the purest devotion to Truth—a thought which many would call irrelevant—which some perhaps might think selfish—yet of which we may truly say—God forbid that it should ever be absent from our minds. God forbid that we should ever forget that the place which our country holds among nations must be fixed by the labours of her children; that their success is her glory; that their defeat or dishonour must fall darkly upon her. If this thought be irrelevant, it has in itself that which must command our attention, whatever else may engage it. If it be selfish, it is selfishness so enlarged, so purified—may I not say, so noble—that it cannot fail to exalt the mind where it is found. And Truth herself will not condemn us, if, with our devotion to her, a thought of Patriotism should mingle. It will not degrade her worship, nor will it render us unfaithful. We shall not love Truth less because we love our country too.

Let none suppose that we are powerless to affect the place which Ireland is to hold in the world, because we are removed from the noisy bitterness of politics or of warfare. Less brilliant for the moment, paling in the glare of military or political success, the pure triumphs of the intellect have a far more enduring brightness. I am sure that

the day will come—if indeed it have not come already—when England shall be known less as the country of Marlborough and of Cecil, than as the country of Newton and of Shakspeare.

Let us work then earnestly, bravely, faithfully, to promote the great objects for which we were instituted, yet not without a thought that we are an *Irish* Academy; remembering that when we labour in the cause of Literature or Science, we labour too for the honour of our country; remembering for her sake, if not for our own, that for the faithful worshipper of Truth, Truth has her own rewards, illuminating his brow with some portion of her own splendour—some pale reflexion of the glories that surround her throne.

XIV.—I. ON SOME FRESHWATER RHIZOPODA, NEW OR LITTLE-KNOWN. FASCICULUS II.—ON AMPHIZONELLA VESTITA (SP. NOV.), ACANTHOCYSTIS SPINIFERA (GREEFF) AND PLAGIOPHRYS SPHERICA (CLAP. ET LACHM.) By WILLIAM ARCHER. (With Plates XII. and XIII.)

[Read December 12, 1870.]

ON a former occasion,* and in another place, I brought before the notice of those interested in types of existence so lowly, a series of forms in certain groups of Rhizopoda, at once novel to our freshwaters, as well as some of them possessing in themselves a considerable interest as connecting links, leading on to their more complex and structurally more differentiated marine relatives. Having, since then, continued to bestow some attention to the subject, I venture to propose to bring forward from time to time, as opportunity may offer, such casual jottings, or accounts of any few additional new forms, as good fortune may enable me.

In bringing forward those I was able to present in my former communication, owing to their heterogeneous nature and their positive and negative characters *inter se* I experienced a difficulty in endeavouring to put them before the reader in anything like a "natural" sequence. In this, and any further communications I may be able to make, my difficulty alluded to is removed, while the disadvantage remains; for I must just submit to take them in such order as accident and opportunity may present them, irrespective of any mutual affinities; and, indeed, this is the less to be regretted, for as yet the freshwater forms, or rather the types they represent, are too few, and their characters too negative, to be able satisfactorily to relegate them to established Classes and Orders. Nor indeed possibly do the freshwaters really possess forms calculated to fill up the intervals or lacunæ between certain therein existent and already recorded

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* Quarterly Journal of Microscopical Science, vol. ix., N. S., pp. 250 and 386; and vol. x., pp. 17 and 101.

representatives. At least, I think, matters must remain as they are in that regard for some considerable time longer.

The difficulties I advert to—as they appear to me—I have already tried as succinctly as possible to set forth,* so that I need not here recapitulate them. I would only just mention, as connected with the question, that, as it would seem to me, the more the "Heliozoan" group are studied, the more closely do certain representatives of them, at least, appear to annex themselves to the marine "Radiolaria," but, yet from such, however, the transition is not abrupt to others whose negative characters would seem rightly enough to forbid their admission into that Order. Nor is this in itself to be wondered at; in all forms of organization the transitions are more or less gradual; and, as bearing on the relations of the Heliozoa and the Radiolaria, it is interesting to note Haeckel's statement in a recent memoir (one as noble and interesting as we yet owe to his busy pen), that the *young* condition of a typical or true "Radiolarian" is morphologically that of a "Heliozoan."† It is scarcely necessary, of course, to remark, still less to urge, that this is by no means a statement that any of the recognized forms which can rank only as Heliozoa are but young or progressive states of forms, which, in course of individual development, are fated to rise to the dignity of Radiolaria. It seems, I think, as if it might rather be interpreted as a statement, that a young Radiolarian indeed may be, from a morphological point of view, but equivalent to a Heliozoan; but whilst the former, by and by, puts on additional characteristics, a *true* member of the latter group can rise no higher, but must remain with its fellows, to present us with a continuous supply, as we find them, of examples of its kind.

Before directly passing on to endeavour to give some account of the forms which I have tried to pourtray in the accompanying drawings—one, at least, new, the others, if not new, at all events, seemingly comparatively rarely encountered and "little-known"—I cannot but make use of the opportunity to reiterate my own view as to the seeming constancy with which the freshwater representatives, at least, of the Rhizopoda maintain their characteristics and special identities, and recur, again and again, more or less commonly or rarely. I cannot coincide with those who hold that their differences are but accidental and casual, being simply due to surrounding circumstances; that, because the *living* part in all throughout is essentially but a little mass or patch of "sarcode," and so all have a pervading uniformity of nature, they are, therefore, all, as it were, but one rhizopod—this protean creature presenting itself to view under various aspects, whose seeming specialities are but accidental and unessential. If, indeed, I have misapprehended the views of Dr. Wallich and others in thinking they hold the extreme opinion I have just indicated, they at least urge

* Loc. cit., vol. x., p. 21.

† Haeckel, "Beiträge zur Plastidentheorie;" in "Jenaische Zeitschrift für Medicin und Naturwissenschaft;" Bd. v., page 530.

that not only are the individual 'species,' in certain types or genera, to a great extent invalid, but would even combine together certain recognised distinct genera as hardly correctly or actually distinguishable individual forms. As regards Difflugiæ, the view propounded by Dr. Wallich seems to be endorsed by Mr. H. B. Brady,* that the differences hese present are due but to the influence of external circumstances.

But I venture to think that such a view is untenable, when, time after time, and season after season, in pools very many miles asunder, or in a familiar single pool, with exactly the same crude materials around, exactly the same substances in suspension or solution in the water, exactly the same kinds of food accessible, and (so far as we can observe) exactly the same influences in action, such as regard light, &c., current or stillness of the water, or such like mechanical or physical circumstances—when, I say, under all these precisely similar conditions we constantly find associated and maintaining their specialities, it may be in one and the same drop of water, a more or less considerable number of forms with more or less mutual affinity, representing it may be several recognized distinct genera, or even families.

There is a little mass of "sarcode" side by side with several other little masses of "sarcode," all very like one another, each of which somehow contrives to build an edifice in which to dwell. An abundant quantity of different and various materials abounds around. Some choose long diatoms, others short; some choose sandy particles or other materials. One form constantly contrives to attach its materials in the roughest and most "slovenly" manner. Is it with a view to the grotesque, or the picturesque, or what? Another form as constantly impacts its building materials with a mosaic evenness and regularity. Is it with a view to turn itself out elegant and spruce? Another form constantly sticks on its materials, externally, so loosely as hardly to deserve to gain credit for any architectural capacity. Is it due to inherent laziness of disposition? Another form wants no such extraneous assistance; its inherent nature admits of a test sufficiently strong being secreted in its own structural development. There are, then, various "sarcode" bodies capable each of making such choice from a common stock of materials, each capable of applying those materials in its own way, whilst to me these and such like specialities seem to be bound up with a considerable amount of constancy in outward figure, and a certain amount of constancy, also, in dimensions, which are more than accidental. Again, there is "sarcode" capable of secreting solid "skeletons" of various types and forms; and, side by side with it, other "sarcode" not capable of this, the external circumstances being alike. There is "sarcode" which makes its "skeleton" a hollow globular fenestrate structure finally external to its own living mass; and, side by side with it, other "sarcode" which makes its skeleton separate por-

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* H. B. Brady, "Analysis and Descriptions of the Foraminifera," in the Ann. Nat. Hist., October, 1870, p. 273.

tions (variously figured "spicules"), deposited in the external region of its living mass; and yet other "sarcode" hard by which produces its solid parts more deeply immersed in its living mass, and in all the external circumstances being alike. There is "sarcode" always colourless, or nearly so—"sarcode" imbued with various variations of hue—"sarcode" bearing certain pigment granules—each speciality bound up with individuality of form, and in all the external circumstances being alike. There is "sarcode" slow in projecting and retracting the characteristic "pseudopodia," and "sarcode" which can send forth and withdraw its "pseudopodia" with comparative rapidity and energy; there is "sarcode" which can send out comparatively very slender and long, even delicately filiform, pseudopodia, and other "sarcode" which cannot project such prolongations, except as little more than, as it were, narrow lobes of its own body-mass, and produced only to a comparatively limited extent; such specialities, in various degrees, seemingly bound up with certain outward figures, and at same time the external circumstances being alike. There is "sarcode" seemingly quite, or nearly all but, rigidly abstinent, with *lots* of food around, and side by side "sarcode" gluttonous to satiety; "sarcode" in whose substance not yet any crude food has been seen; and "sarcode" so *hungry* that, at least, one form of rhizopod exists whose seemingly highest aspiration and even ultimate aim in existence would appear to be to die of sheer repletion—these specialities in various degrees likewise seemingly bound up with certain outward figures, and at same time the external circumstances being alike.

In thus cursorily drawing attention to some of the idiosyncrasies of one "sarcode" as compared with another "sarcode," or, perhaps better, definite patches of "bioplasm" (Beale), I need hardly say I refer now to such as is presented by Rhizopoda only; and, in referring to Rhizopoda, I refer to freshwater Rhizopoda only. "Sarcode" plays a part in higher beings subserving to more exalted ends; but I refer to that which meets our attention in the *pools*, to which my own experience is confined. If, indeed, I were acquainted with marine rhizopodous forms, I might possibly be of a different view in respect to them from that I feel, as yet, constrained to hold as regards their freshwater relatives. Of course, I do not pretend to aver that some of the more minute forms we now and then encounter may not be young or transitory or undeveloped states of certain others; but this would not, I imagine, greatly militate against the *general* correctness of the view for which I here contend; neither do I aver that the various forms we from time to time meet with are immutable, or not subject to a certain amount of modification. I would only venture to urge that such does not appear to be by any means so great as some would hold. I do not now dwell on the fact of "zygosis" taking place uniformly like form with like form; whatever may be the significance of that phenomenon, it is, at least, one which I have noticed myself in numerous forms in all the genera, each individual species always "conjugating," so far as observation reaches, *only* with its *own* fellow.

Nor does a certain amount of difficulty in identifying even some common forms with some of the older authors' descriptions or figures argue materially, if at all, against my view; for I would as yet rather venture to think such difficulty may be attributable, not so much to the deviation of any particular form in question from the *author's* "species," which he may have had before him, as to the original want of completeness in seizing the details, and want of conformity of the author's "description" or figure to Nature's "species,"—if I may rightly here use the term—due, perhaps, in great part to the fact that Nature is so chary in giving us more than glimpses of her doings, and all that the author saw was but a single aspect, or only a few of the features of a form of existence, the rest of which, it might be on that occasion, were screened and hidden from his ken.

Hence I imagine that descriptions of these forms cannot be too minute or too much in detail. If such be as carefully and as closely as possible carried out, and figures made as painstakingly as possible, and examples afterwards found cannot be identified therewith, then that form must present various aspects or phases, and on the next occasion the variations should be noticed, or such examples *may* represent a form essentially distinct. But if, on the other hand, at hundreds or thousands of miles distance, one and the same form turns up, presenting when fully formed the same details, there cannot, I imagine, be a reasonable doubt but that such may legitimately be regarded as a permanent form or "species," if the term be allowed.

With an apology for obtruding these preliminary remarks, somewhat at variance with the views of observers, for whose opinions I have the most lively respect, I proceed to offer an account of my new form.

Amphizonella vestita (Sp. nov.)—Plate XII. Figs. 1-6.

In endeavouring to bring before other more distant students of the Rhizopoda the somewhat variable aspects presented by the *tout ensemble* of the new form I name as above, I shall follow the precedent of my previous communication, giving first a running commentary on the details presented by an examination of a number of examples, the characteristics of which I have made an effort to seize on, in the accompanying figures, and defer short diagnostic characters to the conclusion.

As on former occasions, it may, perhaps, be most convenient to begin the description of this form, as it were, from within outward.

We have, then, a minute sarcode body of what may be said to be normally of a globular figure, not exceeding say $\frac{1}{400}$ of an inch in diameter, but sometimes examples presenting themselves not reaching more than two-thirds of that measurement. The basic substance of the body-mass might indeed be called by some colourless; but, to my observation, it does not quite so appear, but sub-pellucid, and not quite uniform in tint, nor altogether homogeneous in consistence. The hue presented to my eyes is what I may call somewhat clouded, and

varying from a very pale yellowish-brownish, in some places, to a very pale bluish in others, especially at the circumference, and but very slightly granular, while the pseudopodia, and the part whence they emanate, appear colourless, or pale bluish.

In all the specimens I have seen (from three localities), just beneath the outer boundary of this sarcode-body there occurs a stratum of irregularly scattered, generally elliptic, or rounded, but sometimes irregularly figured, very minute, greyish or somewhat purple coloured, sharply and darkly bounded, clear, shiny bodies; these are sometimes comparatively evenly distributed, though without any definite order; at other times more or less crowded in clusters, but do not ever seem to extend quite through and through the body-mass. (Figs. 1, 2, 3.) In nearly all the examples I have seen, taken from two out of the three situations in which I have met with this form, immediately beneath the stratum of bodies just mentioned, there occurred a more or less dense stratum of large and conspicuous chlorophyll-granules of a deep green tint, the green colouring portion in each forming a horseshoe-shaped or crescentic body at one side, leaving an uncoloured portion at the other, as if enclosed in a wall, these mostly imparting to the specimens, at first sight, an appearance almost like some chlorophyllaceous alga (Figs. 1, 2); commingled, however, with such examples occurred others comparatively poor in chlorophyll-granules, and presenting under a low power a yellowish grey colour, the elliptic bodies being predominant, whilst examples from the third locality showed no chlorophyll-granules at all, but abundance of the pale elliptic bodies. (Fig. 3.) Below the stratum of chlorophyll-granules, when present, not however central, but rather to one side, yet not touching the periphery of the body-mass, there presents itself an elliptic bluish-grey-coloured granular-looking "nucleus." (Fig. 1.) Although the sometimes very densely-crowded elliptic bodies, and chlorophyll-granules, render it difficult to discern the nucleus, yet, by a little patience and manipulation, the intervening granules becoming in the meantime altered in distribution, I have nearly always succeeded in gaining a view of this body, without the aid of re-agents; whilst their use, as will presently be mentioned, never fails to disclose its presence. It does not *appear* to be covered by a special membrane or wall.

Having arrived so far in the descriptive building up, as it were, of our form, we have what, if it indeed presented no additional characters, would be simply an Amœba—a variably-figured sarcode-body, bearing a "nucleus,"—for quite similar little elliptic, or rounded little bodies, as well as chlorophyll-granules, also occur in Amœbæ, though I am not aware of the latter fact being recorded; nor would elongate pseudopodia be requisite to exist, as the lobe-like expansions of many Amœbæ are not more than alterations of outline.

But to continue the examination of the form before us, we find that it can do more than alter its outline from orbicular to sub-triangular, or a cornered figure, or present one or more lobe-like projections: it can send forth short, more or less elongate, blunt and

conical, or slender and tapering, colourless or pale bluish processes or pseudopodia. (Figs. 1, 2.) These, for a reason to be immediately explained, mostly emanate from a restricted region of the body-mass, and are very fitful, never kept extended long at a time, nor that often; but further, a few still more fitful and less elongate pseudopodia can sometimes be projected from other parts. (Fig. 2.) The locomotive power of this form appears very restricted. If then our form presented no additional character, it would still be but an Amœba-form, or one, owing to the pseudopodia being of a one-sided tendency, perhaps, approaching Bailey's genus, Pamphagus.

But our form is *more still* than this; and, to continue our progressive examination from the amœba-like form we have reached, we find this so-described body-mass is enclosed in a kind of mantle or coat, closely investing it; and this is of a highly curious and remarkable character, which I shall now endeavour to describe.

When a living example of this rhizopod is first placed under examination, even though its normally orbicular figure be more or less distorted, this outer coat appears not only to surround the body closely at every part, but to form a rim-like exterior in complete union with it; that is, as it were, but a more dense and differentiated, but sharply-marked off, outer boundary to the body-mass, whose changes of figure it necessarily follows. On further examination, it is seen to possess a number of vertically-posed and parallel lines in its substance, and reaching through its thickness, giving a striate appearance to this rim-like investment. This appearance is often very striking; but specimens occur in which it is, more or less, difficult to be made out; yet a little trouble, and it can be seen in all. Further, on the outer surface of this coat, there mostly occurs a dense clothing of more or less elongate colourless, very slender, hair-like processes, of very variable degree of development. Sometimes these attain a length at least equal to one-third (Fig. 1), perhaps even sometimes approaching one-half the diameter of the body of the rhizopod, whilst, in other specimens, these hair-like processes appear much shorter (Figs. 2, 4), giving a merely pilose appearance to the surface, or, so short are they, as even to impart a merely roughened or granular aspect to the surface or periphery of the coat (Fig. 5); and again, they appear in certain other examples as all but obsolete (Fig. 3). An empty coat presents a dotted appearance all over (Fig. 4). These hair-like processes, especially when well-developed, appear, on first examination not unlike pseudopodia, and one might be inclined to suppose we had before us a Heliozoan form (resembling a form, perhaps, referrible to Greeff's genus, Astrodisculus*), rather than one of Amœban affinity; but that, as is seen, would be a wholly incorrect interpretation of the characteristics of our form.

I have said this outer coat appears to form not only a complete

* Greeff, "Ueber die Radiolarien des süssen Wassers," in Schultzes "Archiv für Mikroskopischen Anatomie;" Bd. v. p. 496.

investment at all points to the body-mass, but, *at first sight*, to be even in complete union therewith. But this latter is not the case, for more exact examination of a number of examples shows, not only that it can become locally, though but slightly, removed from contact with the body-mass, but also that, in the majority of cases, a region of the body exists from which this outer coat appears to be absent. That this outer coat is in reality not only a completely differentiated portion of the creature's structure, but even, so to say, an independent part of its organization, is shown not only by meeting occasionally the empty, as it were discarded, coats in the water (Fig. 4), but by the action of re-agents on ordinary examples, as I shall presently allude to (Fig. 5).

I have mentioned that very often a portion or region of the surface of the living sarcode body of this rhizopod appears to be destitute of this coat, around which the latter often appears to thin off, retaining however its ordinary superficial characteristics. And it is from just this region that the greater part of the conical or slender tapering pseudopodia, above described, emanate. Sometimes the outer coat appears to push up here all round, and a somewhat broad projection of the sarcode body comes forth, this giving off a considerable number of the pseudopodia, projecting outwards like a crown, or, may I say, like an "*aurora?*" (See Figs. 1 and 2.) For, like an *aurora*, in a few minutes, the tuft of pseudopodia seems to change, and they perhaps then disappear.

But what is more remarkable, not only do pseudopodia emanate from this seeming vacant part of the investing coat, but the body-mass occasionally can project a short blunt conical pseudopodium, sometimes, even simultaneously two or three, from indifferent portions of its surface. Now the singular circumstance here is, that such a pseudopodium does not, as one might at first suppose, push up the outer coat before it, thus creating an interval or space between it and the body-mass, but, what is more curious, urges or bores its way right through the outer coat, and projects beyond it (Fig. 2). Such a pseudopodium appears to be more transitory or evanescent than those emanating from the ordinary region, and is usually pretty soon retracted. But, what is still more extraordinary, than its boring its way out, is that, on being again withdrawn there is not a trace apparent of the place through which it passed, just as if the aperture in the coat, which must have existed, became (as it were) completely healed up.

Of course the possibility suggests itself that the outer coat may, in reality, be pushed up before the advancing pseudopodium, and in the act becomes so thinned and attenuated as to present the appearance of a naked pseudopodium. But, admitting the possibility that, from its acquired tenuity, the outer coat, which would thus clothe the pseudopodium, would escape detection, still, I think the superficial hair-like processes would hardly be obliterated all along the stretched outer coat, and must present themselves to view, even if seemingly more sparsely

present. But no such appearance is evident; and I have endeavoured, as faithfully as I can, to repeat in Fig. 2 the appearance presented during the period of the extension of no less than two such temporary pseudopodia in the example under view. Another interpretation might suggest itself, which is, that the fine vertical lines seen in the rim-like margin presented by the edge view of the outer coat, may represent so many really existent minute apertures or fine canals in its substance, which may be of a highly elastic nature, and that when the point of an advancing pseudopodium pushes against one of these, the aperture becomes so stretched as to give passage to the comparatively thick conical pseudopodium; and further, that upon its withdrawal, the elastic force comes again into action, and closes up the little fine passage to its normal dimensions. But I would myself be inclined to imagine the extraordinary characteristic of this outer coat, forming so remarkable a part of the organization or structure of the rhizopod, goes even further, and is even more strongly evinced. I have mentioned that from a definite region, from which the outer coat appears to be wanting, emanate the ordinary pseudopodia, and that these can be withdrawn. Now examples are however by no means rare, which, watched for a long time and made to roll over, show no tendency to project pseudopodia nor any difference in the outer coat, which, viewed from various points, seems like an everywhere-present sharply-defined rim, and, as the case may be, more or less pilose or hairy in appearance. I am then half inclined to suppose that even the parts of the outer coat which permitted the exit of the tuft of pseudopodia, or even allowed a prominent portion of the body-mass to project, can again become closed up, and the creature become completely invested at all points by this remarkable outer coat. Nor is such a hermetically closed-in example torpid or "encysted;" it is perhaps quietly all the time assuming various contours, from a nearly globular to various bluntly angular forms; and even perhaps, as I have seen more than once, such an example may send forth unexpectedly, mostly at one or even two of the corners produced, a blunt pseudopodium through the wall. On the other hand, that a certain amount of what may point to the reality of a kind of differentiation into "anterior" and "posterior" ends, may be said to be evinced, not only by the frequency with which examples present themselves with the pseudopodia confined to one space only, but also by the fact, so far as it goes, that the "nucleus" appears usually to occupy a position at the side remote from that of the pseudopodial region, thus *perhaps* offering a certain amount of analogy to several other forms of Rhizopoda, where anterior and posterior extremities are distinctly pronounced, and in which the "nucleus" always occurs behind.

In the progress of our ideal building up of the form now under consideration, and in our gradual advance from within outwards, I purposely left in abeyance a characteristic evinced by the sarcode body-mass—one, however, which appertains to it in common with a great many other Rhizopoda, and to that body-mass itself I must for a

moment revert. I refer to the formation of vacuoles therein. I left the allusion to this in abeyance, because the appearances accompanying its display are curious in relation to the presence of the remarkable outer coat, which I proceeded therefore to describe first.

Although, however, the formation of pulsating and non-pulsating vacuoles is a phenomenon so frequent in various genera of Rhizopoda, their existence in the present form seems to be rather exceptional than otherwise.

Such a specimen as that repeated in my fig. 2 offers, however, an example of this condition in a pronounced degree. Here the whole body-mass is more or less areolated by the presence of vacuoles, and the green and colourless granules are pushed aside, and these run more or less into a reticulately disposed arrangement between the vacuoles, the elliptic bodies naturally falling into a position more or less end to end. But not only do those internal vacuoles exist, but no less than three marginal ones appear in the example figured, showing a distinct pulsation in action, very much like that of the marginal pulsating vacuoles in Actinophrys, Actinosphærium, Heterophrys (*H. Fockii*, mihi) and others.

But, perhaps, the most interesting circumstance connected with these pulsating vacuoles is the way they stretch and seem to attenuate the outer coat, as seen in two of those present in the example figured (Fig. 2). I have not been able to see that they caused an opening in the coat; at all events, on collapsing, the latter had quite its ordinary aspect. From the appearance here presented, we see something like what I imagine ought to reveal itself before an advancing pseudopodium, did not it actually penetrate through and project beyond the outer coat, as I have already conveyed. The third marginal vacuole in the rather energetic example figured occurs on the broad projection giving off the pseudopodia, and seemingly here without the covering of the outer coat. Unlike the marginal vacuoles of the Actinophryans, these were slow in action, pulsating only a few times and disappearing, nor recurring after a long time of waiting, until finally the dip dried up.

But our form occasionally, indeed rarely, presents yet another characteristic: this I have tried to repeat in Fig. 3. This consists in the somewhat sudden appearance of a fitfully more or less deep *halo* of very pellucid sarcode matter, outside the whole body-mass and outer coat—sometimes involving the example completely round—at other times seemingly developed over only a portion of the superficies. So far as my observation reaches of the occurrence of this curious-looking envelope, it has presented itself only in the examples from the third locality (county Tipperary), and in those without chlorophyll-granules, and in which, too, the hair-like appendages were least developed, or, as in the example figured, all but obsolete. Whether, however, there is more than meets the eye in the circumstance just mentioned, I must leave in abeyance. But, to describe the appearance presented more closely: one is watching an example in the hopes that pseudopodia may be extended, or to have a view previous to treating

the example with a reagent, and perhaps nothing particular as yet discloses itself, when, I might say, all of a sudden, there appears to grow off, as it were, from the periphery, an, at first, homogeneous, pellucid, rather sharply-bounded, nearly colourless, or, very faintly bluish, sarcode border, either nearly simultaneously all round, or at one part only first; or it may be that this never, during protracted observation at least, presents itself universally. The first time I noticed this seemingly sudden growth of this very subtle, or, as I might almost say, of this etherial-looking covering, it was certainly with some surprise. One watches, and this delicate halo grows here and there broader, again narrowing here and there, keeping up this play for a length of time; and so the border, hardly ever at any one time of equal depth for any long stretch, thus presented more or less of a broadly-lobed outline. The broader and more pronounced this envelope gets as one watches, the more readily is seen in its very attenuated-looking substance, when focussed equatorially, a number of radial lines, beginning at the surface of the outer coat, and reaching to its own outer contour. These lines are not always like continuous striæ, but of a dotted or somewhat *shaky* (so to say) appearance. A moment more, and probably they cannot be discerned; and yet, in a brief interval, they seem at once and all round to reappear. When these dotted lines are about most pronounced, so also, though always sharply marked off, is the edge or outline of the hyaline investment most pronounced, and the lines seem there to broaden, and form a bluish margin to the whole, this again soon becoming paler and disappearing. I have tried to realize the most pronounced appearance of this pretty condition in my Fig. 3. After a short while again, perhaps, this beautiful play ceases, and this hyaline investment disappears, nor leaves any more any appreciable evidence of its having been.

I have said, there is *sarcode abstinent* and *sarcode voracious*—these idiosyncrasies as if bound up with certain forms, and maintained, so far as I can see, seemingly irrespective of the *supplies* around. Our rhizopod does not at all belong to the former category, but neither is it a hungry form. Crude food within its substance is not abundant, nor, as a matter of course, are the objects incepted large in dimensions, consisting seemingly only of minute protococcoids, and such like. In the first gathering in which I met this rhizopod, there occurred numerous examples of a curious little chroococcaceous alga (one endowed with a locomotive power, and one which, I may parenthetically observe, well deserves in itself a closer investigation, to which I may hope for an opportunity, should I refind it, to return on a future occasion), and this organism seemed therein to form its principal food. Fig. 2 represents a vigorous specimen, which has more than once afforded us instructive details in connexion with its behaviour, and which contains a specimen of the alga referred to, which it had incepted. Fig. 3 shows a small protococcoid which has been incepted.

Having, then, thus tried in idea to build up the structure, step by step, or to give such a descriptive picture, as it were touch upon touch,

of our form, as well as having made an endeavour in the figures, by the aid of the brush, to realize its likeness, I trust I shall have succeeded in conveying to observers a fair and available representation of this rhizopod, in some of the somewhat varied aspects of its living condition. I must, however, devote a few words to a record of how far the behaviour of this rhizopod, under the action of certain re-agents, bears out or explains the preceding account of its structure, and then speak of its seeming affinities, and assign it to its genus.

On the application of Beale's carmine fluid, a collapse of the whole form, coat and all, takes place; the green granules become more glassy in appearance; soon the whole, coat and all, begins to swell out again as globular as before; no retraction of the sarcode body-mass from the coat seems to ensue, nor any dissolution of the hair-like external processes. The body-mass by-and-by becomes granular in appearance, and far less hyaline. But the most important effect produced by this valuable re-agent, is the unfailing certainty with which it brings to view the "nucleus," by reason of the extent to which this body absorbs the carmine colour, until by-and-by it assumes an intense red colour, far in excess of the pale rose tint presented by the remainder of the sarcode-mass. The nucleus appears as before, mostly slightly longer than broad, and sharply bounded. Sometimes a second rather sharp outline is apparent a little within the outer one; the former of which, when present, bounds a space more highly coloured than the border beyond it. This, however, appears to be exceptional, and although in the living condition the nucleus appears evenly granular, its substance now appears smooth and homogeneous. This experiment then is very satisfactory, as disclosing the presumably constant "nucleus," but it does not seem to demonstrate the body-mass and its outer investing coat as independent structures; for, altered in appearance as may be the former, and though some of the granular contents, and even some basic sarcode may become extruded, the body-mass and the coat still seem to remain closely applied to each other.

The application of acetic acid does not seem to produce any very noteworthy effect, save rendering the outline of the nucleus more sharp and marked. No very evident contraction of the body-mass from the coat took place. But this experiment I have not tried sufficiently often to rely very much upon its general results; and I imagine I did not succeed in bringing this reagent to bear with sufficient energy.

The use of a re-agent I happened to have by me for another purpose, a weak solution of iodine and iodide of potassium, was attended with very pretty results. This reagent, vigorously applied, caused an immediate contraction, or rather coagulation, of the sarcode body-mass into one or several balls, the whole coming clean away from the outer mantle or coat; when allowed to act more slowly, the result of the gradual retraction of the body-mass as above can be seen. If, indeed, the finding of empty coats (see Fig. 4) in the material did not already prove the independent character of this investment, I mean its want of organic union with, that is, its being no mere condensed

exterior, or thickened and consolidated, and altered ectosarc to the body-mass, I think this experiment would demonstrate the point. If the rhizopod and its investment were like "endosarc" and "ectosarc," I should suppose that this experiment must also have given, in this regard, a similar result to the preceding. But this experiment, the effect of which in a single specimen I depict in Fig. 5, gave other curious results. As I have already described, the body-mass presented a stratum of the pale, shiny, elliptic bodies, just under its periphery, and immediately beneath this, in the majority of the examples, they presented also the more or less dense stratum of bright chlorophyll-granules; and within all, generally at the side most remote from the pseudopodium-bearing region, they admitted of being seen (with patience) the elliptic "nucleus." Now the immediate effect of the present re-agent was, as it seems to me, highly curious and interesting. I have said the sarcode mass coagulated into one or several balls, leaving the mantle bare, but not only did it do so, but these balls, in contracting, carried with them and *huddled* together the elliptic shiny bodies, which in the normal state formed the outer stratum, or that the more distant from the centre; whilst, at the same time, the chlorophyll-granules were left outside the contracted sarcode balls, though they, in the normal state, formed the inner stratum, or that nearer the centre. Thus, a complete transposition taking place in a moment, that which had been the outer being carried in, and those which had been the inner left out. Further, in the majority of the instances in which this experiment was tried, the nucleus was likewise not included by any of the sarcode balls, but left outside as a somewhat shrivelled or lobed pale greyish-bluish coloured, rather shiny, body; in other instances, however, I could not again find the nucleus, and it must have either been embedded in some of the balls of sarcode or ejected, and got lost. The action of the present reagent on the mantle or coat itself, seems to be that of causing its expansion or inflation, as it assumed a nearly circular and somewhat enlarged outline; the specimens which happened to be experimented upon, were some in which the external hair-like processes were very short, yet quite distinctly marked, nor did the action of the re-agent cause any very great alteration in their aspect, whilst the general surface retained the colourless character and the dotted appearance due to the linear markings in the substance of the coat, or to the hair-like processes themselves; whilst at the periphery, just as in the normally empty coat, where a thicker mass of the substance is seen rim-like, and where, of course, we thus look through a greater density, it appears of a bluish colour. Upon adding a very little of the ordinary tincture of iodine, the coat took a straw colour, the other portions remaining as before. This experiment, therefore, was not without very instructive results.

The action of sulphuric acid was also interesting. Brought to bear very slowly at first, this time upon examples showing no chlorophyll-granules, this re-agent caused a slight inflation or expansion of the total rhizopod, coat and all, simultaneously. One specimen, pre-

senting two lobes, from which pseudopodial projections were pushed out, presently assumed a more orbicular outline, and the pseudopodia disappeared. These were examples which possessed rather long, hair-like external processes. At first they were not seemingly affected by the action of the acid, neither was the mantle or coat, and I had begun for a moment to query were these hair-like processes of a rigid and siliceous nature, but the results soon gave a negative reply. By degrees there took place a *slight* widening of the hair-like processes, from being of a fine linear appearance, as in the normal condition, so that I could attribute to them a certain amount of width and, as I might say, two sides; these seemingly somewhat wider below or during their length than at the acute apices, that is slightly tapering. They could not, then, be siliceous. Presently a few of these processes seemed to *drop off*, and showed a *slightly* capitate lower extremity, and several showed a more or less curved figure. I tried, in Fig. 6, to convey an idea of the appearance such detached processes now presented to me. But, perhaps, the most interesting result followed the application of a stronger dose of sulphuric acid, when at once the outer coat, hair-like processes and all, became quickly dissolved, leaving the sarcode body a naked somewhat sharply-bounded globular mass, the contained granules broken up, the pale elliptic bodies dissolved or disappeared. The result of this experiment was, therefore, not less satisfactory than the preceding in demonstrating, though in a reverse kind of way, the complete difference and independent character of the outer coat and the inner sarcode body-mass.

I have to add, that any re-agent applied to an individual showing the faint and pellucid outer investment, already described and attempted to be pourtrayed in Fig. 3, causes its immediate disappearance, even though its action be too weak to call forth any of the previously mentioned results.

All these experiments, then, seem to me to corroborate and shed a light upon the interpretation previously advanced of our examination of the structure of the living rhizopod. Perhaps, indeed, some may think the word "structure" misapplied to a being so lowly, and, after all, so little differentiated; but, at least, like other Rhizopoda, it cannot be denied its special characteristics, even by those to whom one *sarcode-patch* is the same as another *sarcode-patch*, each of which is only moulded into this or that *by accident*. Here is a "form," at all events, which may or may not be independent, but such a form in its "specific" details, so far as I am aware, as has not yet met observation. Until, then, it proves to be but a transitory form, it possesses quite as distinguishable features as very many others constantly recurring; it has presented itself in three distinct localities—one some hundred miles or more distant from the two others—and, on the whole, deserves a record as well as more familiar types.

But having now gained as much acquaintance with the characteristics of this rhizopod as present research has disclosed, we may just for a moment speculate as to the analogies, so to say, of its composition.

The central body of all, the so-called "nucleus," is, of course, quite homologous with the similar so-called body in Amœba, in Difflugia, in Diaphoropodon, in Pleurophrys, in Euglypha, in Cyphoderia, in Plagiophrys, in Pamphagus, &c., &c. The tapering hyaline non-coalescing pseudopodia have the essential characters of an "Amœban" rhizopod, whilst the contractile vacuoles, if not exactly alike, much resemble them, but still more those of an "Actinophryan." The pale shiny, mostly elliptic, granules are again found in Amœba, and related Rhizopoda, and are probably equivalent to the "sarcoblasts" (Wallich) of Amœba; whilst the chlorophyll-granules of the present are again seen in some Difflugians as well as *various* other Rhizopoda, temporarily in some, or possibly constantly in others. The special and very remarkable and very puzzling character of the investing mantle or coat would place such a form as ours out of all the older "Amœban" genera. This coat is at once yielding and plastic, elastic and tough, seemingly capable of being bored through and effacing the aperture—*possibly*, however, minutely perforate—and is clothed with processes of variable length, these separable under certain re-agents, as if in a measure articulated, resisting some re-agents, at once disappearing under the action of others. This is, therefore, not a test comparable to that of Difflugia, or Euglypha, or Plagiophrys, &c. What, too, may be assumed to be the nature or *homology* of the outer hyaline investment, depicted in Fig. 3, and described above? Does its existence at all point to the presence of actual canals in the coat indicated by the vertical or radial striæ, and is this an emanation poured out through such canals, comparable to the ectosarc of an Amœba, or is it rather to be regarded as "chitonosarc" (Wallich)* ? If, indeed, the mantle or coat described be not, as I have throughout regarded it, a truly external investment, but a wall placed between the inner body-mass and an always existent, though, on account of its very pellucid and subtle nature, seldom visible, outer region of the total rhizopod, then the existence of little actual canals need not necessarily be assumed. Perhaps, even such an assumption may not, after all, be quite unfounded, for though this *halo* is rarely evident, yet a kind of bright outline often presents itself immediately external to the striate coat, which, however, I have rather been inclined to ascribe to an optical effect than to the visible expression of the existence of an actual outer investing sarcodic stratum, however delicate, or of however slight depth. Might the fine vertical lines seen in the substance of this subtle covering actually indicate the very moment of formation or deposition of the hair-like processes? The weak action of the sulphuric acid seems to have the effect of dislocating (some, at least, of) these as if they were, in a measure, articulated to the coat.

While, then, much that is puzzling and enigmatical remains unsolved, enough is evidenced to show the immediate "Amœban" affinity

* Wallich: "On the Polycystina," in "Quart. Journ. Micr. Science," vol. v., N.S., page 71.

of this form. But while it cannot appertain to any of the genera Amœba, Difflugia, Arcella, or other more distantly related types, as Pleurophrys, Plagiophrys, &c., it is, perhaps, sufficiently fitly referrible to an Ambœban genus lately established by Greeff—I mean Amphizonella—to find a place legitimately there, at least, temporarily, and until further research may possibly show its specialities to demand its removal, or show its nature and affinities to be distinct therefrom.

Having then, from what has preceded, gained a conception of our rhizopod and its characteristics, as I have said, the next step is to assign it to its generic position—one which, as we have seen, is peculiar. However, the "genus" which it might typify, as I have mentioned, I think I find already instituted by Greeff in his Amphizonella,* and it will therefore be necessary that I should here endeavour to convey a conception of that genus, and of the three forms referred to it by Greeff, which I may here mention have all occurred not in water, but damp earth. This, indeed, may be the more advantageous, as no account of it exists in English works, nor have hitherto, so far as I am aware, any of the forms referrible to it have been recorded in this country, though I now myself have little doubt but that I have seen on one occasion his typical form, *Amphizonella violacea*, though at the time I paid far too little attention to it to note its specialities, or even as yet to venture definitely to announce its occurrence; but I have little doubt but that proper search must again disclose it.

Greeff does not give, unfortunately, any diagnostic characters of his genus, so that one has to construct, *in idea*, gleaned from his general description, such a type as would include his forms (and mine), and exclude other "Amœbina." And this type, briefly expressed, seems to be an Amœban body, *plus* a hyaline coat, penetrable by the pseudopodia, its previous condition recoverable, and strangely resistant to the action of some re-agents, and at once succumbing to others, yet quite soft and yielding in its natural condition.

But now to recapitulate Greeff's account of his principal or typical form, *A. violacea*, following his words as closely as may be without altogether a full or precisely literal word-for-word translation:—

Amphizonella violacea (Greeff.)

"The fully-grown individuals of this form have" (says Greeff) "a diameter about 0·15^{mm}, and are of a more or less globular figure, which undergoes little change, even during the movements of the rhizopod. This rotund body shows a hyaline outer margin, and an inner mass mostly coloured a beautiful violet. At first glance (says the author) we might suppose we had before us the ordinary structural condition of an Amœba, that is a particularly dark and coloured granular endo-

* Greeff, "Ueber einige in der Erde lebende und andere Rhizopoden," in Schultze's "Archiv für mikroskopische Anatomie."—Bd. ii., p. 323, t. xviii., fig. 12, 13, 14, 15.

sarc, with a hyaline ectosarc universally surrounding the former. But upon closer examination it is seen that this external layer represents a completely independent margin or border, ('Saum') with an outline of its own both outwardly and inwardly, and which equally surrounds the body proper of the rhizopod. All round the circumference can be seen the limits of this border ('Saum') in apposition to the surface of the inner body-mass. . . . . Still more clearly can this be seen when the outer investment is burst by compression, and some of the sarcode mass ejected. . . . . . .

"Upon the application of re-agents, the distinction of this outer coat, ('Hülle') as a special and an independent part of the structure from the inner body, becomes even more decidedly expressed. Under acetic acid, whilst the body-mass loses its pigment, collapses, ejects the granules, and shows every indication of coagulation, the outer hyaline 'capsule' ('Kapsel') remains quite intact, and this even though the acid be allowed to act in a more concentrated condition, or for a longer time. The same thing takes place under dilute sulphuric acid, whilst on this being applied in a more concentrated form, the capsule wholly, and the contents partially, become dissolved. However, during the dissolution of the capsule no other alteration takes place, that is, no sign of coagulation or the like. . . . . . Under the action of alkalies this capsule shows at first a tolerably persistent resistance, afterwards, however, becoming dissolved, without, however, having become previously altered in appearance. The action of iodine is remarkable: so soon as this, in a dilute form, is applied, the violet colour becomes destroyed, and its place is taken by an at first clear yellow colouring of the whole of the contents, which gradually, under prolonged action, passes over into a deep blackish-brown, all which time the outer border maintains perfectly its colourless hyaline appearance, and only when penetrated at all sides by the iodine does it acquire a slightly yellow appearance, which, however, upon its being removed by blotting paper and water added, again disappears. Only under persistent action (of the iodine) does the capsule become tinged a light yellow, retaining, however, its pellucid glassy appearance.

"From all this" (urges the author) "it follows that, as regards the problematic hyaline outer border in Amphizonella, it is not a protoplasma-layer appertaining to the rhizopod body, but that we have really to do with a comparatively thick 'capsule,' bounded off and essentially distinct therefrom.

"As regards the body-mass included by this capsule" (the author goes on to say), "this is permeated by a mostly dark-violet pigment; frequently, however, it assumes a trace of yellow or brown; and this again depends upon a second pigment diffusely distributed in the body, which, under circumstances hereafter to be mentioned, sometimes presents itself exteriorly. Under natural conditions, and without pressure on the covering-glass, little can mostly be made out as to the contents, owing to the darkness of the colour, with the exception of the vacuoles always existent in considerable numbers, though minute, as well

as a large round body (nucleus), which structures make themselves evident by their somewhat clearer appearance. The violet colouring substance is, however, very sensitive, and readily destroyed by the gentle action of acids, alkalies, alcohol, iodine, &c., and then the contents, having become considerably clearer, can be examined. Sometimes compression succeeds in extruding and isolating, uninjured, the contents and the most important parts. Amongst the varied kinds of food expelled (Diatoms, Arcellæ, Euglyphæ, &c.), a large round body, the "nucleus," at once strikes the eye. This measures about 0·04^{mm} in diameter, and has a rather soft consistence. This resembles in structure that of Amœba." [The author here adduces that of his *A terricola*, previously described by him: a perfectly hyaline investment surrounds a space which is completely filled with round solid granules, and the author has every reason to suppose that the progress of development of these granules is essentially the same as in *Amœba terricola*, although he has not yet been successful in observing the transitional forms. The author here alludes to a breaking up of the nucleus and scattering around of the granules, each one the germ of a young Amœba, by successive stages, putting on the character of the mature form—see the preceding portion of this memoir on *Amœba terricola*]. "The young of *Amphizonella violacea*" (continues Greeff), "or what appeared allowable to be regarded as such, were still destitute of the above-described hyaline outer coat, and were naked, as if it appeared those were developed only at a certain stage;" [the author adds, however, that these conditions demand a closer investigation.]

"The movements of this creature" (says the author) "are peculiar—the contractions and modifications of form of the whole body take place exceedingly sluggishly, and the form must be observed carefully and persistently in order to make one certain about them. These consist ordinarily of only slight undulate projections from the circumference of the body, the roundish form of which only exceptionally passes over into an oval. In all these general movements of the body the outer capsule takes a constant, if, indeed, only a secondary part, in that it readily yields to every impulse outwards of the inner body.

"The movements of the sword- or finger-like pseudopodia, projected from the interior, evince themselves differently. These project forth with a perfectly hyaline blunt apex, pushing on in advance only a simple contour, never [according to the author's observation] the double contour of the outer coat, thus proving that the latter becomes perforated with readiness, by the inserting of the cuneate process." [The author adds, that] "This fact is confirmed by the circumstance that the pseudopodium can be frequently followed through the outer capsule down to its basis—that is to say, to its origin in the interior of the body-mass. Ordinarily, the pseudopodia do not extend outwards beyond a certain limit, remaining hyaline throughout the whole length; if however, they become more elongated, which rarely happens, then a dark and coarsely granular substance streams forth from the interior into them, not, however, pressing on further than about half-

length. These motions are more vigorous than those of the body in general; they usually come forth rapidly, but only when the creature has been permitted to remain for some time at rest and undisturbed, disappearing again just as quickly upon any jar.

"If we revert to the outer capsule, we find it showing wonderful peculiarities—on the one hand, an extraordinary resistance to outer influences (as before detailed), and on the other hand, as it appears, a soft and gelatinous consistence, readily permitting the penetration of the pseudopodia, and, without doubt, after their retraction, filling up the openings produced in the substance by fusion at those places." [Touching the latter point—that is the ready fusibility of the substance of the capsule—the author next communicates a peculiar observation, one at same time of further interest.] "This was an extremely curious fusion, or firm hanging-together (seen, however, only on one occasion) of two individuals. The capsules only were here fused together by their margins, whilst the two body-masses remained free, and without any connexion. This latter was, however, brought about by a peculiar indirect way, by a commissure of clear yellow hyaline substance proceeding from one individual to the other, of which substance mention was made above as a pigment sometimes occurring in the contents. This commissure originated on both sides, with a broad basis, taking up almost the one half of the circumference of the inner body, giving the appearance as if it flowed out therefrom, and it formed at the place of union an isthmus (or bridge), passing through the hyaline capsule-substance. The question becomes [says the author], what significance is to be attributed to this remarkable object—whether it represents an individual just about to undergo self-fission, or an act of reproduction, described for other Rhizopoda under the name of conjugation or zygosis? [Although meantime the author was not in a position to prove either the one or the other for want of further observations on the object, he gives his adhesion rather to the interpretation of the case he describes as one of zygosis, from his having observed the young forms of the animal, as previously mentioned, which are distinguished by the want of the outer hyaline 'capsule.'] "From these and other reasons (the above described nature of the nucleus), one might be justified in attributing to this form a sexual reproduction, or rather a development of a young brood in the interior of the mother-body, and not a propagation by fission."

The foregoing recapitulation (expressed in the third person) presents the account given by Greeff of his type-form nearly in full. To make the data more complete, by which readers of the present communication can the better realize the generic idea of Amphizonella, in which my own new form seems to fit, I add in the same manner, but slightly contracted, all he has to say of the next form, called—

Amphizonella digitata (Greeff).

As a second representative of the same genus as the foregoing (i.e. *A. violacea*), the author points to the form named *A. digitata*, presenting,

as he describes, the same characters of structure and movements—"that is, an universally closed hyaline outer coat or capsule, with extremely pale digitate processes projecting through the latter. In *A. digitata* the separation of the hyaline protoplasm of the rhizopod from the outer capsule is still more distinctly evident, since the first surrounds the granular interior substance as a more or less broad stratum. The motions are more vigorous, and are indicated by the fact that mostly at first broad hillock-like processes, still encompassed by the outer border, become pushed forth, from whose ends then the digitate pseudopodia project. The granular inner parenchyme (endosarc) shows for the most part a coarsely granular substance, which, however, appears enclosed in an extremely finely granular one. In the interior there is to be seen constantly a large round nucleus, with a likewise comparatively large and sharply-bounded nucleolus, and besides mostly a large and a couple of smaller contractile vesicles. Likewise, the above-mentioned lime crystaloids are never absent. The animal reaches a diameter of about $0{\cdot}1^{\text{mm}}$."

This, then, is all Greeff has to say on this form, and he gives no more close description. All his forms, however, are illustrated by figures.

Yet, a third form, named *Amphizonella flava*, is (provisionally) referred by Greeff to the genus typified by the two preceding forms, and I would complete the data to enable the conception to be gained thereof by giving his words thereon:—

Amphizonella flava (Greeff).

"Although" (says the author) "I at first hesitated to refer the form to the same genus as the preceding, still I may do so, be it, perhaps, but provisionally. This is likewise surrounded by a coat, but a much firmer one, as it would appear a peculiar "cuticular shell" ('häutige Schale'). This 'shell' ('Schale') is of a light yellow colour, and, unlike that of the two previously-described species, is not directly applied to the body proper of the rhizopod, but lies round about it as a wide sac, and thus follows the contractions and modifications of the inner body, so far as these touch its walls, but always with a certain tenacity, whereby continually alternating folds and lines travel over the surface. Nevertheless, the 'skin' ('Haut') possesses an extraordinary extensibility, so that sometimes it becomes stretched, by the pressing forwards of the processes of the inner body, to an extremely thin and delicate layer, which may be carried on to such a degree that the skin at this place appears quite white, whilst in its ordinary condition, as above mentioned, it is of a yellow tint. Sometimes (says the author) I saw pale, long, hyaline processes from the interior press against the outer 'capsule,' but I was unable to establish with certainty whether the latter became broken through in the previously described manner thereby. It appears, however, undoubted

and even essential, that this problematic 'skin' must, in fact, possess such an extensibility and elasticity, that it becomes ultimately broken through by bodies pressing against it, be it from without inwards by inception of food, or be it by projected pseudopodia. But just as undoubted and essential is it also, that subsequently, as well following the incepted food-particles, as after the pseudopodia are again retracted, the breaches which had taken place should become at once again restored, through the elasticity and easy fusibility of the skin.

I was not able to find a nucleus in the interior of the granular parenchyme, but, however, some minute contractile vesicles; its dimensions reach a diameter of $0{\cdot}04^{mm}$."

This, then, is all Greeff gives us in connexion with these interesting forms. It is a pity his account of the two latter forms is so short, but should they turn up in other quarters, his figures would most likely render the identification not difficult. It is perhaps also, to a certain extent, a pity that he calls the outer coat by such varied names as "Hülle—Schale—Haut—Kapsel—Saum," &c., when, perhaps, the more general term "Hülle," might at least be preferable, that part of the structure being at all events one and the same thing throughout. Combining, however, what we have learned respecting my own new form, brought forward on the present occasion, with what Greeff has communicated of the three he has named, we gain a conception of a seemingly distinct generic type of rhizopod, previously to his memoir, not recorded, at least not defined, and one of considerable interest.

It may look somewhat like temerity, on my part, to essay to do what Greeff has unfortunately left in abeyance; that is to try to comprehend in a diagnostic form what appear to be the characteristic or essentials of this genus, so far as observation reaches.

Genus, *Amphizonella* (Greeff).

Generic Characters.—Rhizopod, with a "nucleated" body-mass, enclosed in a distinct (and separable), more or less pellucid, elastic and yielding investment, through which it temporarily protrudes a greater or less number of digitate or tapering, short, hyaline pseudopodia, upon the retraction of which the extemporized openings in the investment become effaced by virtue of its inherent fusibility.

Affinities and Differences.—The "nucleus" and the digitate, or short tapering pseudopodia presented by the forms appertaining to such a genus as the foregoing diagnosis may, perhaps (so far as present information goes), successfully define, seem at once to stamp its "Amœban" affinity. There might be thought to be some resemblance—nay, close affinity, to Greeff's Astrodisculus,* but the want of the so-called

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* Greeff, "Ueber Radiolarien und Radiolarien-artige Rhizopoden des süssen Wassers," in Schultze's "Archiv für mikrosk. Anatomie."—Bd. iv. p. 496. t. xxvii.

"nucleus," the presence of the "central capsule," and of the numerous exceedingly slender filiform (not short digitate or conical) pseudopodia of that genus, as far as I can see, completely place the forms referrible to it apart from the present and amongst "Radiolaria." I have no doubt that I have now myself met with more than one Astrodisculus-form, but so sparingly, that I have yet had no opportunity to submit them to anything like a sufficient examination. But though the Amphizonella-forms are then "Amœban," in their affinity, they seem generically quite distinct from all such recorded previous to Greeff's memoir, by the special and peculiar character of the outer coat. Possibly, further research may disclose transitory stages in development of the forms referrible here, which may present conditions falling short of those assumed as typical in the present state of knowledge about them, but as yet I venture to think the genus must be taken as a "good" one.

It seems exceedingly probable that the form named by Auerbach,* *Amœba bilimbosa*, ought to be referred here; this has not, however, so far as I am aware, been ever rediscovered. Many of the characteristics described for it seem to point to a community of structure with such as the present, and, therefore, in fact, to its necessary exclusion from Amœba proper, notwithstanding that Auerbach has endeavoured to demonstrate that "all Amœbæ are encompassed by a universally-closed membrane, which is structureless, very extensible, and perfectly elastic." To combat this view, however, is no part of the object of this communication, nor to give a *resumé* of Auerbach's now well-known memoir, to which I would refer, however, as interesting in connexion with the present forms. Still, however, Auerbach's experiments, with re-agents or otherwise, do not seem to have produced a separation of the body proper from the closely-investing covering, that is, they do not seem to demonstrate their, so to say, independent character.

Descanting, however, upon this outer, doubly-contoured investment, which he was inclined to regard as nothing else than the presupposed cell-membrane, which he would ascribe to all Amœbæ, and, alluding to the mode of projection of the pseudopodia and the thinning off and interruption of the investment where they occurred, Auerbach goes on to say:—"Allein indem ich länger beobachtete, wurde ich über diese Ansicht bedenklich. Namentlich war mir das Verhalten der Contouren an der Basis der Fortsätze ein Stein des Anstosses. Ich hielt es für unwahrscheinlich, dass eine dicke Zellenmembran an einer so scharf begränzten Stelle so sehr sollte verdünnt werden können. Deshalb warf ich mir die Frage auf, ob ich nicht vielleicht Rhizopoden mit einer membranösen Schale vor mir hätte, welche an gewissen Stellen für auszustreckende Fortsätze durchlöchert wäre." And, with the light thrown by the knowledge of the form described in the present

* Auerbach, "Ueber die Einzelligkeit der Amœben," in Siebold and Kölliker's "Zeitschrift für wissensch. Zoologie." Bd. vii., p. 374 (1856).

paper and of those made known by Greeff, does it not appear that Auerbach's conjecture in the foregoing extract is right: in other words, that if it should turn up once more it is highly probable that *Amœba bilimbosa* will reveal itself as appertaining to Amphizonella (Greeff)?

A form of rhizopod, described as involved by a very flexible "membranous tegument," met with by Dujardin, to which he has given the generic name of Corycia,* seems, possibly, to come close to this genus. The account given by him, unaccompanied by any illustration, is, however, too meagre to be certain as to what it actually is; it does not *seem*, however, to be the same thing as *Amœba bilimbosa* (Auerbach); it probably most resembles one of the forms referred to Amphizonella by Greeff—*A. flava*—but is most likely not specifically identical therewith; a decision in respect to it must, I fear, remain in abeyance.

I have sometimes thought that the unnamed rhizopod referred to by Focke† in a recent paper, simply under the designation of "No. iii." (loc. cit.) might be closely related to my form, here named *Amphizonella vestita*. But the account given by that author of the form he had in view is far too brief and meagre to be able to arrive at an opinion. Could his figure possibly represent such a form as mine, no pseudopodia present, and with very long and comparatively coarse, hair-like external processes? or could his form possibly rather represent an Acanthocystis? So uncertain does it, however, appear to me, as regards its true character, that I would here simply content myself with referring to his communication, and leave the determination of his rhizopod and its possible relationship here, through such as that I now bring forward, to the future.

Possibly, should any of the now four (perhaps I might write five or even six) forms referrible here be encountered by observers in this country, an attempt likewise to embody their seeming individual specialities, as well as those of the present new form, in short characters, may not be quite without use (leaving, however, *Amœba bilimbosa* (Auerb.) and *Corycia* (Duj.) in abeyance). I may begin with Greeff's type-form—

Amphizonella violacea (Greeff).‡

Large, mostly rotund in figure; nucleus large, enclosed in a hyaline wall, filled with solid granules; the granular body-mass permeated for the most part by a dark violet pigment, imparting that prevailing colour which, however, towards the exterior, is varied somewhat by another diffuse yellowish or somewhat brownish pigment; the pseudopodia colourless, conical, blunt; the investing coat colourless, of varying depth or thickness, outwardly smooth.

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* Dujardin in "Annales des Sciences Naturelles, 1852," p. 241.

† Dr. G. W. Focke: "Ueber schalenlose Radiolarien des süssen Wassers," in Siebold and Kölliker's "Zeitschrift für Wissensch. Zoologie," Bd. xvii. p. 355, t. xxv., iii., a, b, c.

‡ *Loc. cit.*—Bd. ii., p. 323, t. xviii., fig. 12, 13, 14, 15.

Amphizonella digitata (Greeff).*

Medium-sized, variable, and mostly lobed in figure; nucleus large, containing a comparatively large and sharply-bounded nucleolus; body-mass colourless, coarsely granular at the central region, inclosing, however, a further finely granular substance containing lime crystalloids; outer marginal region hyaline; pseudopodia colourless, very short, conical and blunt; the investing coat of less depth than in A. violacea, *uniform in thickness, smooth.*

Amphizonella flava (Greeff).†

Minute, variable in figure; nucleus not detected; body-mass colourless (?), *granular; pseudopodia pale, hyaline; outer coat standing apart from the inner body, pale yellowish, very thin, smooth, often falling into folds.*

Amphizonella vestita (Arch.)‡

Minute, but variable in size, normally rotund, but capable of varying its figure; nucleus comparatively large, elliptic, granular, smoothly bounded, but not seemingly enclosed in a special investment; body-mass nearly colourless, or bluish, varied by a palish-brownish hue, enclosing a number of minute clear shiny purplish-grey, generally elliptic, sharply bounded corpuscles, these forming a stratum just under the periphery of the body, below which often occurs a more or less dense stratum of large bright chlorophyll-granules; pseudopodia hyaline, generally emanating in a cluster from a comparatively restricted region, but occasionally singly from other different points, short and conical, or more elongate and tapering, bluntly pointed; investing coat colourless or faintly bluish, thin, and of uniform depth, often seemingly deficient at the region giving off the corona of pseudopodia, at other times seemingly completely covering the body, showing a number of sharply-marked, closely and vertically-posed equidistant lines, seen, when viewed equatorially, in its substance reaching through its depth, and clothed superficially with a dense covering of more or less elongate extremely fine filiform hair-like processes, giving a hirsute or pilose or narrow fringe-like appearance, or, when empty, a dotted aspect, or these obsolete.

Measurements: Diameter varying from about $\frac{1}{400}''$, down to perhaps two-thirds of that size.

Localities: Pools in Co. Westmeath and Tipperary. In the latter locality no specimens were seen showing chlorophyll-granules—a temporary character however in many Rhizopoda.

Affinities and Differences.—Considerations which would fall under this head, so far as they have a bearing in a generic point of view, and so far as the genus Amphizonella is typified by Greeff's forms, have been already adverted to. In respect, however, to our new form,

* Loc. cit., p. 328. I. xviii., fig. 18.
† Ibid., p. 329, I. xviii., fig. 19 a, b.
‡ Pl. xii., figs. 1–6, accompanying this Paper.

it might suggest itself just possibly that certain considerations might operate in a measure to exclude it from one and the same genus with Greeff's. I allude to the mostly one-sided emanation of the pseudopodia and the seeming absence of the coat at a given area and to the presence of the superficial hair-like processes, and the subtle hyaline sarcode envelope sometimes seen. The first circumstance might be thought to bear a parallelism to conditions constant in Pamphagus, Lieberkühnia, &c., separating them from their allies—the second to represent a definite anterior opening (thus unlike Greeff's forms)—the third to present a distinct portion of the organisation of the total rhizopod not evinced by Greeff's forms—and the last, a greater amount of differentiation, or of superaddition of parts, indicating a certain advancement. But we have seen that all these are variable characteristics evinced in various degrees: these variations in reality, taken all together, constituting so much of the sum total of the characteristics of our rhizopod, whose nature is to show now some of them, now others, more prominently, or in a more pronounced manner—in other words, these characteristics, though attaching themselves to the *species*, are not of *generic* significance. Greeff's figures of *A. violacea* convey the idea of the pseudopodia being confined to a separate region, but he does not speak of this in the text. The peculiar elastic and yielding outer coat, penetrable by the pseudopodia, would *seem* to be the great character of the genus, coupled with the Amœban body, and in that our form agrees. I need hardly say, its distinctions *in itself* from Greeff's three forms are sufficiently striking. The vertical parallel closely-posed lines in the outer coat do not exist in them, nor do they show the hair-like processes, nor (of less importance) have they ever shown chlorophyll-granules. Indeed it is unnecessary to contrast them very rigidly or closely. Its possible relationship to Focke's "No. iii." (loc. cit.) has been above alluded to. "Affinities and Differences" can, however, be regarded from at least two points of view—a morphological and a developmental. From the former point of view enough has been demonstrated, indeed, to determine as to our form; from the latter, nothing very reliable has shown itself to me. I have no doubt, however, but that earlier or later phases occur without a coat, and that it seems to be formed subsequently, as in Greeff's forms, and others appertaining elsewhere. My data in that regard are, I regret to say, only obscure and conjectural. Should good fortune ever yield an opportunity to gain any insight into these points in connexion with our form, I may at some future time revert to our rhizopod herein described, which, morphologically viewed, seems to stand as a good species, and it may, for the present at least—with a double allusion, on the one hand, to the often well-developed covering of hair-like processes, and, on the other, to the less often seen hyaline and subtle outer envelope—pass as *Amphizonella vestita.*

Acanthocystis spinifera (Greeff).

In my preceding Fasciculus, I gave a description of a new form appertaining to the genus Acanthocystis (Carter), named by me *Acanthocystis Pertyana*,* and on discussing its relations and resemblances, under the head of "Affinities and Differences," I had naturally occasion to contrast that form with the one it most approaches, the above-named *Acanthocystis spinifera* (Greeff),† and I drew attention to the distinctions between the two forms which, indeed, still appear to me to hold good.

That occasion afforded me, also, the requisite opportunity to give a *résumé* of Greeff's views and ideas as to the supposed or conjectured further developmental stages, or at least assumed modified conditions, of his form. He conceived, namely, that the yellow globules occurring in the body-mass of *A. spinifera*, becoming extruded therefrom, involved in a hyaline covering, then give off opposite pencils or tufts of very slender and delicate pseudopodia, and at last acquire characteristics of which he gives figures.‡ Further, he conceived that those afterwards may become combined into considerably larger groups, the slender and delicate pseudopodia being now confined to the outer or circumferential parts of the cluster or aggregation of such bodies, of which he also gives a figure.§ The first of these forms, as I then adverted to, is identical with that previously named *Diplophrys Archeri* (Barker),‖ and the second with *Cystophrys oculea* (mihi),¶ and I followed up a review of that portion of Greeff's memoir, by some considerations which appeared to me to render his views hereupon, as yet at least, improbable, and therefore to indicate that those names should stand.

Amongst those considerations opposed to Greeff's conjecture touching *A. spinifera* and the other forms alluded to, was adduced the negative, and far the least important one, indeed—that is, that whilst the latter occur with us not very uncommonly, the former had not yet been found in this country.

Now, the object of the present additional brief note is threefold—first, to correct what turns out to be a misstatement on my part as to the non-occurrence of *Acanthocystis spinifera* in this country; in the next place, to point out certain features in the accompanying drawings, (Pl. xii., Figs. 7, 8), which seem to be of possible interest in connexion with this elegant form; and lastly, to draw attention to two drawings (Pl. xii., Fig. 9, and Pl. xiii., Fig. 10), which I take the opportunity to insert in the Plates, of the little organism, already alluded to by me, possessing so great a resemblance to a Diplophrys, pseudopodia retracted and surrounded by an aggregation of foreign bodies,**

* "Quarterly Journal of Microscopical Science," vol. x., N. S., pp. 101–3.

† Greeff: "Ueber Radiolarien und Radiolarien-artige Rhizopoden des süssen Wassers," in Schultze's "Archiv für mikrosk. Anat." Bd. v., p. 493, t. xxvii., Fig. 20–3.

‡ Loc. cit., fig. 26–28.

§ Ibid., fig. 29.

‖ "Quarterly Journal of Microscopical Science," vol. viii., p. 123.

¶ Ibid., vol. ix., N.S. p. 265.

** Ibid., vol. ix., N. S., pp. 323–4, and vol. x., N. S., pp. 102–3.

although there is, so far as I can see as yet, no evidence that, though to a certain extent so very like, it actually has anything to say to that form, and still less to *Acanthocystis spinifera*, nor have I, indeed, any thing to add to the crude record I have already given of it.

I must now own that I ought to have put forward the statement, that *Acanthocystis spinifera* (Greeff) did not occur with us, in at least a more qualified manner, for I was then, and have long been, acquainted with what I now feel very well satisfied is no other, the yellow globules, however, not present, and varying comparatively a good deal in dimensions. But it was not until subsequent to my previous communication having been published, that I met with fully characteristic examples, confirming Greeff's description, so far as relates to the form itself, in all particulars—the well-marked outline of the presumed "central capsule" —the numerous yellow globules immersed in the body-mass, but exterior to the "capsule"—their occasional extrusion through openings made by the temporary displacement of the long, and fine, and slender equal-sized pointed radial "spines"—in fact, all the described characteristics presented themselves to observation. The examples previously met with by me I now regard as simply smaller, and probably young states of one and the same form, the "capsule" not yet formed nor yellow globules present—or indeed these, perhaps, but few or faint in colour; in fact, Greeff himself states, these do not always occur. Such examples I had, indeed, before me in my "mind's eye" when I wrote, but kept a mention of them in abeyance, imagining they might probably be younger states of *Acanthocystis turfacea* (Carter), and required further observation. It is true the spines here are different from what is characteristic of that species, but it struck me they might, by fresh accretion, eventually assume their ultimate varied lengths and bifid apices. I admit such an assumption was gratuitous, the more especially after a perusal of Greeff's memoir, and due consideration of the characteristics of his *A. spinifera*.

I have now, however, no hesitation in recording this form (*A. spinifera*, Greeff) as occurring in this country; for, besides the more minute forms alluded to I have lately taken a number of perfectly typical examples from both County Westmeath and County Tipperary. Of the smaller forms I have tried to re-produce an example in Fig. 8, to which I shall presently advert, first drawing attention to the features illustrated by Fig. 7, representing a preparation after treatment in Beale's carmine fluid.

Amongst the points illustrated by the example before us (Fig. 7), the first that may probably attract notice is the fact that we have here two individuals in a state of "zygosis." This phenomenon is occasionally seen in all Rhizopoda, but is, perhaps, more noteworthy in those "Radiolarian" forms, like the species of Acanthocystis, which, unlike those of "Amœban" affinity, are altogether surrounded by a kind of wall of solid parts (spicula) which might be supposed to interfere with, or act as a bar or hindrance to, the mutual fusion of the sarcode bodies. However, not only the present form, but likewise *Acantho-*

cystis turfacea (Carter) and *A. Pertyana* (mihi) sometimes present themselves in this condition, and the present pair of examples of this form, so "conjugated," have not been chosen by me for illustration merely on that account. Whilst as yet regarding such an example as that seen in Fig. 8 as a younger specimen of *A. spinifera*, yet it may be worthy of mention that even such minute forms occasionally present themselves "conjugated"—just a possible argument, indeed, that they may be actually distinct, supposing "zygosis" to indicate "maturity." It might, however, be held by some that such a condition does not really represent a case of "conjugation" of two distinct individuals, but rather of incomplete self-fission of a single individual; but, although the true import of the phenomenon remains very problematic, still I think a consideration, to be mentioned below, seems to indicate that this does not represent an act of mere division, but really represents two "individuals" in a state of fusion or "zygosis." Accepting it as true that so it is in the case before us, perhaps the only circumstance directly connected with this particular condition really worthy of being drawn attention to, is, that the radial or vertical spines are distributed seemingly as evenly over the broad connecting isthmus, or commissure, as at any other portion of the circumference of the conjoined pair of individuals, showing that during the original act of fusion, by mutual putting forth of a projection from each inner sarcode-body, the spines must have become raised up thereby, and, as it were, *shunted* aside, so as still, however, to come to stand vertically on the exterior of the broad connecting *isthmus*. There is no apparent line of demarcation evident between the two conjoined individuals; nor could it be decided, as regards certain of the spicula, standing, as it were, half-way, to which of the conjugated individuals they may have originally belonged; nay, it is just conceivable that, after separation, there may even take place an actual mutual interchange of a few of these.

But the point which most of all deserves consideration in the specimen before us, and probably that which would next attract attention on looking at the figure, is indicated by the small bright red round body at the middle of each of the "conjugated" pair of individuals, the high colour presented being due to the extent to which the carmine dye has been absorbed. I would here refer to Greeff's figures of living specimens of this form* to show the appearance presented by the presumed "central capsule," which I was able very well to see in many of the examples I have had under examination. In relation to this form and its central body, Greeff nowhere, however, goes so far as to call it a "central capsule" (he refers to it as a "centrales kernartiges Gebilde;" in another place as "Kern;" again, as "centrale Blase"). But to the very similar, nay, seemingly quite identical-looking body in species of Astrodisculus, he does not seem to hesitate to apply the term "central capsule." To my eyes, this has here a somewhat solid-looking aspect and appears colourless, and of course pre-

* Loc. cit., t. xxvii. Fig. 20, 32.

vents the intrusion of any of the granular contents of the "extra-capsular" region of the inner sarcode body. We have then, in the conjoined specimen, shown by my Fig. 7, the outline of this "central capsule" still faintly indicated, but which has not acquired any higher colour from the carmine solution than that of the extra-capsular region; but the minute round body in the centre of each, as before alluded to, has imbibed the colour very strongly. Now the question at once presents itself, what does this little rounded central (here highly dyed) body represent? If, indeed, observers will go so far as to conceive that the structure first described by Greeff in this form be truly homologous with the central capsule of the marine Radiolaria, then I would venture to suggest that the more minute (highly dyed) body occupying the centre of each of the conjugated individuals in the figure, may represent the *vesicula intima*, or inner vesicle ("Binnenblase," Haeckel). If, indeed, I may be correct in that assumption, then this will be the first instance (so far as I am aware) in which that element of the organization of a typical "Radiolarian" has been perceived in any *fresh-water* representative. Still it is a portion of the structure that I believe would be quite impossible to detect or see in this form in the ordinary condition of the fully-grown rhizopod, owing, I may presume, to the solid or opaque appearance of the "central capsule" above alluded to. At least, I fear, I should never myself have suspected the existence or have seen it in such examples without the application of the re-agent.

But the experiment illustrated by the figure having shown the actual existence of such an inner body, leaving its precise homology in abeyance, I naturally was anxious to refind some of the more minute, and, therefore, less opaque and less granular forms, which, as I have said, I would be much inclined to regard as younger examples of *A. spinifera*, in order to submit such to a more critical examination. Fortunately a gathering, just made in County Tipperary, revealed a few such, and of one of these I endeavour to give a portrait in Fig. 8, which indeed though so minute, seems to give a certain indication of the yellow globules, though faint in colour. I had now, however, no difficulty in perceiving in the centre of such a minute example a delicate pale and colourless globular little body, whose nature can admit of but two interpretations, one only of which, of course, can be the true one. It is either a structure quite homologous with that represented in Greeff's figure, and indicated also in mine (Fig. 7), in fact, the presumable "central capsule," or else it represents the inner minute body, so deeply dyed in the example figured. Probably, had the very small specimens in this particular gathering been sufficiently numerous, the experiment of the application of the carmine solution would have assisted to decide the point; I could not succeed, however, as yet in bringing it to bear on any of those minute specimens. But, although I must leave the question an open one as yet, I may draw attention to the consideration, that, if the little central body in Fig. 8 really represents the same body as figured by Greeff, and readily seen in examples taken by myself—the presumed "central capsule"—it ought to be

larger in proportion, as this generally occupies in this form a comparatively considerable extent of the body, and, that, therefore, so far as I can yet form an opinion, it should rather be regarded as equivalent to the body dyed red in the example in Fig. 7, that is *presumably* homologous with the *vesicula intima* ("Binnenblase," Haeckel). If, indeed, this be really so, then it may be asked: where is the structure surrounding it or the central capsule itself? Perhaps, then, the answer to this query may be, that the latter is *not yet* formed, and that the *vesicula intima* is the *first* produced. On this point I may call to mind, that Haeckel himself informs us that a time exists in the young condition of a veritable and altogether typical marine Radiolarian, in which no "central capsule" exists.*

Having thus, in the case of *A. spinifera*, been able to demonstrate, at least in undoubted typical examples, two differentiated structures, one within the other, which may seemingly as yet legitimately be interpreted as "central capsule" and "inner vesicle" ("Central-kapsel" and "Binnenblase"), I was naturally desirous to experiment upon the form described by myself in my preceding Fasciculus, *Acanthocystis Pertyana*, and, fortunately, some specimens lately turned up, though I regret I have been unable to prepare a figure in time for insertion in the present Plate. In my previous description of *A. Pertyana,* I stated that no "central capsule" nor "nucleus" could be made out, nor indeed can such be perceived by mere examination of an ordinary living example; it is to be regretted that I had not at command at that time Beale's useful carmine fluid, for its application has disclosed at least an equivalent structure to that in *A. spinifera.* In this form, however, the result of the application of this re-agent was not quite the same as in the case of *A. spinifera;* for, though a smaller round central body took quite as high a colour as that in that species, yet, unlike it, the presumable "central capsule" likewise became comparatively highly coloured, but by no means so intensely as the more minute inner body, both one and the other becoming individually very clearly marked off, with a sharp outline.

Of course the appearances presented in even both forms, resulting from the experiment described, might be capable of a different interpretation—that is, that these structures, in place of "central capsule" and "inner vesicle" may represent rather "nucleus" and "nucleolus;" but I should myself as yet be more disposed to accept the former view, supported as it is by the analogy of the structure of the marine forms —a view in which I imagine most other observers will rather be inclined to acquiesce. Bearing on this point, I may perhaps have an opportunity to offer some notes on a future occasion relating to certain other rhizopods.

Regarded, however, in *either* light, the presence of these central structures in *each* of the conjoined examples in Fig. 7, would seem to go to indicate that they are really two distinct *individuals* mutually

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* Loc. cit., p. 530.

"conjugated," rather then truly only one individual becoming two by a self-division.

The specimen before us (Fig. 7), happens to present a further characteristic, which, perhaps, may be worthy of just a passing note, for no light can be thrown on its possible significance. I allude to the presence of the rather large, opaque, colourless, shiny, somewhat pearly-looking, broadly-elliptic body immersed in the sarcode body-mass, and between the two conjoined bodies of the "conjugated" pair of individuals; this seems homogeneous, and does not seem to show any nucleus or wall. It appears, I think, to be a precisely similar body to that recorded and figured by Stein, as present in examples of his so-called *Actinophrys oculata*, themselves conjoined or conjugated.* Upon this problematic body, Stein himself seems to be able to throw not any light, thinking it however an introduced foreign body, and referring to Cohn's remarks on a similar body in *A. Eichhornii* (which see). I should myself hardly be disposed to attribute its existence here to a result of the "zygosis" or "conjugation," for quite identical bodies occurred in the extra-capsular region of unconjugated specimens in the same material; still, it might possibly be supposed in their case, too, that such may be produced in someway as a result of conjugation, and that, after separation, one of the individuals may have borne away with it this peculiar-looking body. I have also sometimes seen similar-looking bodies in the substance of certain other Rhizopoda. Although, then, the significance of this structure is so obscure, it seems to be too conspicuous and prominent a constituent of the *tout ensemble* of the present examples to be altogether unimportant, but a decision as to its nature must be left for further observation.

Another point presented by the examples shown in my Figures (Fig. 7, 8) relates to the *yellow* globules appertaining to *Acanthocystis spinifera*. Greeff seems to suggest the probable identity or homology of these with the green chlorophyll-granules of *A. turfacea*, and of those again with "yellow cells." I believe, however, they are here nothing but oil-globules. Greeff depicts them as all of one light yellow colour; they appear rather of various hues, ranging from a pale yellow to a deep orange, and even a bright coppery colour, in one and the same individual; they are of very shiny appearance and of varied sizes—in fact, altogether like admitted oil-globules in other organisms; they have no "special wall," no "nucleus"—their varied and bright appearance, when present, renders this form one of singular beauty. Greeff very correctly describes the fact that they sometimes come forth from the rhizopod, not indeed simply, as I regard them, as isolated oil-drops, but these are surrounded, as he mentions, by a *halo* of pale sarcodic-looking substance. They *then*, no doubt, very closely resemble what would be a very minute form of Diplophrys (Barker), wanting, however, the tufts of pseudopodia. But I must still observe that to my eyes they

* Stein: "Die Infusionsthiere auf ihre Entwickelungsgeschichte untersucht." p. 163, t. v. fig. 27, x. and x.; also Pritchard's "Infusoria," Pl. xxiii., fig. 25.

do not seem identical either with that form or with the individual globules of the form I named *Cystophrys oculea*. I would here beg to refer to my previous remarks thereon.* I have occasionally since then taken examples of both one and the other, still maintaining the characteristics and appearances they originally presented. It will, perhaps, not be unconnected with the subject to mention here, that, since my preceding communication appeared, in which I stated I had not then seen anything like Greeff's figure 25 (loc. cit.), I have now had more than one opportunity to do so. The specimens I have seen, however, were like, but in one respect not identical with, Greeff's. His figure shows the pencils of pseudopodia as proceeding from the exterior margin of the four juxta-posed bodies, whereas the pseudopodia in mine emanated from the clefts or intervals between the four bodies. Now these bodies were considerably *larger* than the yellow bodies, with their surrounding *halo*, emanating from certain specimens of *Acanthocystis spinifera*, and go far to indicate that Diplophrys can repeat itself by a complete subdivision into several. Bearing in mind that this form is characterised by the possession of two tufts of pseudopodia given off from opposite ends, and that one of these tufts sometimes is projected and not the other (not unfrequently, indeed, neither), the difference between the position of the place of origin of the pseudopodia, shown in Greeff's figure 25, and in my examples referred to, may be probably explained by supposing that, in the former, one set of pseudopodia were predominant, and in the latter the other set were those rendering themselves conspicuous. I must admit, however, that the whole question of the relations of the forms, just now adverted to, is as yet problematic; and it may take a long time, and the result of many fortunate observations, but seldom indeed obtained, to dispel all obscurity that may exist.

I have taken the opportunity, as possibly not unconnected with the question, to insert on the accompanying Plates a couple of sketches of an organism, previously adverted to by me,† very enigmatical in itself, but curious as presenting so close a *resemblance* to a specimen of Diplophrys without pseudopodia, or these retracted, and irregularly surrounded by a cluster of minute diatoms and fragments of larger diatoms, as well as various fibrous elements and indescribable "bits of things," forming a kind of "nest" in which it occupies the centre. Sometimes this "nest," is almost wholly made up of diatoms (Fig. 9), and at others heterogeneous in materials, and sometimes not any diatomaceous frustules are to be seen (Fig. 10). This aggregation of foreign bodies seems to be held together by a very delicate and very pellucid, colourless connecting medium, but what relation this latter may have to the body itself is problematic; the whole usually possesses a decided more or less oval general shape, although, as in undoubted Diplophrys, the body is nearly quite orbicular, not rarely, however, more

* "Quart. Journ. Micr. Science," vol. x., N. S., pp. 101-3.
† Loc. cit., vol. ix., N. S., p. 323-4; also vol. x., N. S., pp. 102-3.

or less, though but slightly, longer than broad, that is, broadly-elliptic. The body suspended within has the faintly granular aspect and somewhat palish-blue hue of that of Diplophrys itself, and the same larger or smaller orange or amber-coloured shiny oil-globule—this oil-globule, not always uniform in shade, sometimes a reddish-orange at one side passing off into a greenish-yellow at the other. This form occurs of various sizes. It has never yet shown any pseudopodia or other external portion of structure, nor any movement. It is widely distributed in this country, though not abundantly present in any gathering made; nor, indeed, is it often encountered, which, however, may be due rather to its very minute size causing it to be overlooked; it is, however, more frequently seen than Diplophrys, though the latter sometimes occurs more numerously in a gathering than the former seems ever to do. A curious question arises as to when or how this puzzling organism, so inert, as it appears, can collect and pose the heterogeneous foreign bodies forming the "nest" in which it becomes embosomed.

In thus once more drawing attention to the forms immediately in question, in this additional note thereupon, I do not suppose the subject is by any means disposed of or exhausted; it is quite possible that, by good fortune, some new or unexpected features in connexion with them may become revealed. Should such occur to myself, I trust I might be once more borne with in reviving allusion to *Acanthocystis spinifera* or its allies. Should such occur to others, I should hail with a lively interest a record of their observations.

Plagiophrys sphærica (Clap. et Lachm.).

In the course of this and my preceding communication, I have sometimes made allusion to the form which I am inclined to believe must be identical with *Plagiophrys sphærica* (Clap. et Lachmann);* it is, at all events, one which now and again sparingly presents itself from various localities. If, however, I am quite correct in this identification of the rhizopod I have had in view, it has struck me that the figure (loc. cit.) is not sufficiently graphic; still, had I not lately met with some examples, not altogether coinciding with that which I had previously known, and which, for the present at least, I must continue to regard as Claparède and Lachmann's species, I would not (as yet at least) have thought it desirable to attempt a drawing of the form. But, though certain specimens lately taken present some distinctions from the former, and on that account it has appeared to me to be perhaps worth while to endeavour to convey a likeness of both, I am, however, not as yet sufficiently satisfied that these are truly two distinct rhizopods, and I content myself with simply submitting the drawings to the notice of other observers whose experience may assist in throwing a light on the question.

* Claparède and Lachmann: "Études sur les Infusoires et les Rhizopodes." P. 454, Pl. xxii., Fig. 2.

But, although I am disposed, at all events provisionally, to regard the first rhizopod I have in view, and attempt to repeat in Plate XIII., Fig. 11, as *Plagiophrys sphærica* (Clap. et Lachm.), still, on comparing our form, after a prolonged examination and experiments with re-agents, with Claparède and Lachmann's diagnosis, I am at the first step met with a character which might seem possibly to exclude it from the genus Plagiophrys. I allude to the fact that those rhizopods, meant to be included here, are said by the authors to be comparable to "Actinophryens non cuirassés," and whose numerous pseudopodia originate in a tuft from a single portion of the surface of the body. But if those authors deny a *test* (they ordinarily use the word "coque") to the (two) forms included in Plagiophrys, they attribute to *Plagiophrys cylindrica* (a form I have never encountered) a *skin* ("peau"), whilst in respect to *P. sphærica* they are silent in this regard; but it is, I imagine, exceedingly probable that, so far as concerns this, the account given of each should coincide, and were most probably meant by the authors to be so understood. But, beyond the fact that the figures represent the forms as possessing a quite smooth surface and sharp outline, there is no evidence afforded of the so-called "skin." The question, then, becomes, what they meant exactly to convey by that term; but presumably it must have been, not a separable integument enclosing the sarcode body (certainly not a test or "coque"), but only a more dense and hardened, or rather toughened, exterior to the body, forming therewith a single inseparable whole, both being in complete organic union, and thus, only that it is less yielding, hardly, if at all, more than what has been attributed even to Amœba itself by some observers, as Auerbach and others. And, in fact, I had myself several times met with the rhizopod I am still disposed provisionally to regard as Claparède and Lachmann's form alluded to, and that without perceiving any further differentiation into body and integument than that I should suppose those authors were inclined to attribute to it.

Hence the experience, presently to be adverted to, gained from the preparations of both my forms under Beale's carmine fluid (Fig. 16), and under acetic acid (Fig. 12), does not appear to militate against the correctness of the identification of the first form here figured with *Plag. sphærica*, for in the living example this outer *case*, or *covering*, is always so closely applied to the body as to appear indeed no more than a smoothly bounded exterior, which might seem possibly, to a certain extent, to be comparable to a "skin."

But, although I cannot but suppose the identity of the form I sketch in Fig. 11 to be probable, as I have mentioned, I regard this determination as yet as but provisional for certain other reasons.

The first is that my form shows a distinct "nucleus," or body so called. Now, in this regard Claparède and Lachmann are silent concerning their *Plag. sphærica*, but they distinctly state they were unable to detect this in their *Plag. cylindrica*. Still, as this is only evidence of a negative character, it does not disprove the identity; for, owing to the density of the contents, the nucleus may have been pre-

sent in both their species, but have been overlooked by them. When our form (Fig. 11), alluded to, is treated with the carmine fluid the nucleus takes a deep dye (Fig. 13), and when treated with acetic acid (Fig. 12), it is mostly ejected and can be seen as a sharply-marked-off elliptic body, or sometimes somewhat kidney-shaped in figure, and of a granular appearance and bluish colour like that of many other kindred Rhizopoda, but does not appear to show any wall or surrounding investment, though sharply bounded.

Probably, then, a stronger reason—one, indeed, that to some however may appear really but a very weak one—for doubting the strict identity of either of my forms with Claparéde and Lachmann's, resides in the seemingly different character of the pseudopodia, as seen in their figure, and as may be gathered from the text. In referring to the figure given by those authors I need hardly here guard against a possible misconception in supposing it is meant to be indicated that the pseudopodia originate equatorially from the periphery of the orbicular body, which would be contrary to the description. The specimen is drawn as viewed from above, the posterior part being towards the observer, and, though the pseudopodia really originate in a single tuft from the side turned away, they appear of course, seen from that point of view, to radiate around. In fact, all Rhizopoda of this character, that is, giving off the pseudopodia exclusively from an "anterior" end (such as Euglypha, Arcella, Difflugia, and many others) have a decided tendency to turn up (so to say) vertically, and creep, by action of the pseudopodia, along the surface on which they find themselves. In fact, it is hard to get a "Plagiophrys" to remain very long presenting to the observer a side or profile-view. The distinction, however, to which I allude is the coarse, granuliferous, and unbranched character of the pseudopodia, as shown in Claparéde and Lachmann's figure as compared with the slender and hyaline and tufted tree-like bundle of very fitful pseudopodia presented by our form. In fact, the authors attribute to their genus Plagiophrys "Actinophryan" pseudopodia; now the form I have in view does not possess pseudopodia comparable to those of an Actinophrys nor to those of any heliozoan species. It is quite true "Actinophryan" pseudopodia sometimes inosculate, or even, occasionally, can temporarily divaricate, but I do not think they ever form a shrub-like or tree-like perpetually altering tuft, somewhat quickly appearing, branching, waving, extending, contracting, and, perhaps, as quickly disappearing, or at other times somewhat rigidly maintaining themselves as a little *tree*. To some these may appear as too fine-drawn distinctions, but I cannot yet but think that these idiosyncrasies are, on the whole, characteristic in these forms.

On the other hand, apart from these distinctions, we have in our rhizopod a minute globular body, with at least *slender* pseudopodia, emanating in one bundle, from a single little depression (or "boule," Clap. and Lachm.) at one side, and with an integument, which might perhaps, when seen only in the living example, appear only as a

"skin" (Fig. 11), and thus, at all events, to a considerable extent falling in with the authors' description of their form.

But when our form is treated with acetic acid the body completely retracts from the integument, and it is shown as an independent, colourless, and smooth coat or case, or—may we call it—"*test?*" (see Fig. 12), thus proving a characteristic not claimed for their forms, at least to this extent, by Claparède and Lachmann, something more, in fact, than what would, I think, be called a mere "skin"—might not our forms, indeed, be designated as "cuirassés"?

But to advert, then, to the mutual differences presented by the examples lately met with by me (Fig. 14), as compared with the form here designated *Plagiophrys sphærica* (Fig. 11). I found it impossible to attain a good profile view of one of the former, so, like Claparède and Lachmann themselves, in this instance I have been obliged to be content with a figure drawn from the posterior aspect. Comparing, then, the form we are the more familiar with (Fig. 11) with that more recently met with (Fig. 14), we see the colour of the body, or rather contents, is much darker in the latter (Fig. 14); this indeed is probably of but little moment; the wall or exterior appears even thinner, smoother, sharper, more glossy. We see, too, the pseudopodia far more conspicuous, longer, here and there more broadened out, granuliferous, more fitful and changeable, and, so to say, of a more solid character, less hyaline; but all this, it may be, requiring far more observation to decide as to its being specially characteristic of truly distinct forms. The differences under the action of Beale's fluid are more tangible. Specimens of the rhizopod, represented by Fig. 14, upon being treated with this re-agent *immediately* collapsed, and assumed the *crumpled* appearance indicated by the outline shown by Fig. 15. In a few minutes this crumpled form began to expand, and speedily the folds all became obliterated, and the whole inflated, until a balloon-shape was assumed (Fig. 16). After a time some of the sarcode mass became expelled through a rather wide truncate neck-like anterior extremity, and the body-mass became distinctly retracted from the outer case (test?); the nucleus took a bright red colour. Sometimes, but by no means in every instance, there was to be seen a brighter, smaller, "nucleolus-like" (?) dot within. In the instance figured, a couple of yellow oil-like globules presented themselves, very like the yellow globules of *Acanthocystis spinifera* (Greeff), and, in my opinion, seemingly largely going to prove that in that form these cannot be at all properly regarded as homologous with "yellow cells." The other specimens (Fig. 11), those of the presumed *Plag. sphærica*, also treated with the carmine fluid, behaved somewhat differently. No collapse or crumpling-up of the total rhizopod took place; on the contrary, rather, by degrees a slight expansion. Nor was it for a very considerable time, comparatively, that the nucleus took its dye completely, nor was there any apparent retraction of the body-mass from the outer envelope, nor did the latter become balloon-shaped, but its anterior border assumed a very broadly conical figure, no very evident apical opening offering itself to view. But that there is, and indeed, as

a matter of course, must be, such an opening, is shown by the specimen treated with acetic acid (Fig. 12); for here the contents becoming retracted, are partially extruded, and even the nucleus expelled through the rather minute aperture at the apex, this frontal region assuming an appearance showing two transverse annular folds, giving a zig-zag lateral outline. It is this portion which, in both examples, in the living state is pushed inwards, giving the depressed and folded appearance then seen—the "boule" of Claparède and Lachmann. The anterior opening therein, indicated in Fig. 12, though seemingly so very small, must, however, be of considerable power of expansion to allow the entrance of so comparatively large an object as that shown within the specimen represented by Fig. 11, which presents an example of *Cosmarium cucurbita* incepted as food.

All this, then, seems to evidence that there must be attributed to these beings more than a *skin*—a distinct and separable *test;* and this would bring the forms very close to Euglypha and Trinema in a generic point of view; and, in fact, the widest distinction is the facetted test of the forms appertaining to those genera, and the absolutely smooth one here; moreover, the behaviour of the pseudopodia is not alike in those. In a specific point of view, be these two, here drawn attention to, really mutually distinct or not, which I leave an open question, I need not urge that neither could for one moment, either in form or habit, be mistaken for any described Euglypha, or for Trinema. But, besides the smooth test, our forms are distinguished from those genera by the flexible infolded frontal region of the test, so unlike the rigid necklike aperture of theirs, as the case may be, either prolonged externally or introverted.

In thus bringing forward these two forms to notice, I own they require a great deal more research; perhaps, then, I may hereafter revive attention to them, should I obtain for any future observations the fitting opportunity.

DESCRIPTION OF PLATES.

Plate XII.

Illustrating Mr. William Archer's *Paper—On Freshwater Rhizopoda.*

Fig. 1. . . *Amphizonella vestita* (sp. nov.) showing the "corona" of pseudopodia, the outer coat, with its vertical, radial, and parallel markings, its clothing of very fine hair-like processes, the subjacent elliptic colourless bodies, a dense stratum of chlorophyll-granules beneath same, and the internal elliptic "nucleus;" the latter, in this specimen, posed at the side most remote from the pseudopodial region. In this example the chlorophyll-granules are very abundant; no crude "food" making itself apparent.

FIG. 2. . . Another specimen of the same, chlorophyll-granules not so abundant as in the foregoing, nor the superficial hair-like processes so long, showing several vacuoles, three at the periphery—two of which, at the point of greatest distention, press up the outer coat—the third, on the bare pseudopodial region; showing, also, two conical pseudopodia projecting through the outer coat; a minute reddish-coloured alga has been incepted as food. This specimen did not disclose the "nucleus;" but there could be no doubt that further examination would have revealed it, but it was desirable to sketch the example with its natural appearance as regards the other details.

„ 3. . . Another specimen of the same, showing the stratum of elliptic bodies, but neither chlorophyll-granules, nor pseudopodia, nor vacuoles; the "nucleus" is, however, apparent; this example, though fitfully changeable in contour, presents no apparent opening or vacant region of the coat, the hair-like processes not evident, and is surrounded by a somewhat deep, changeable, very subtle, hyaline, bluish sarcode-envelope, showing faint vertical lines in its substance. A "protococcoid" is seen immersed in the body-mass, previously incepted.

„ 4. . . Empty coat of another specimen of the same found in the gathering, evacuated by the sarcode body-mass, but a few chlorophyll-granules and elliptic granules (accidentally) left behind. The outer hair-like processes are but short; the general surface presents a coarsely dotted appearance.

„ 5. . . Another specimen of the same after application of a weak solution of iodine and iodide of potassium; the sarcode body-mass has become retracted from the outer, slightly hirsute, now globularly expanded coat (thus proving its distinct and independent structure), and has become coagulated into several balls, these having retained in their substance the pale elliptic granules, but left outside the chlorophyll-granules as well as the "nucleus," which latter is seen to the left, having assumed a contracted and lobed, internally homogeneous, externally smooth, appearance.

„ 6. . . Three of the hair-like processes which had become somewhat expanded and then detached from an example of the same, after the at first slow action of sulphuric acid, and then showing a slightly capitate basal extremity and pointed apex.

„ 7. . . A preparation by treatment with Beale's carmine fluid of an example of "zygosis" in *Acanthocystis spinifera* (Greeff), showing in each of the "conjugated" individuals the central presumed "*vesicula intima*," the outline of the presumed "central capsule," the problematic opaque, colourless, shiny, elliptic body, the ordinary yellow oil-globules, and the outer linear and pointed spines; these latter as equally distributed over the connecting isthmus as over the periphery of each of the conjugated individuals; the specimen being "killed," pseudopodia, as a matter of course, have completely disappeared.

„ 8. . . A very small, presumably a young, example of the same in the living condition, showing the minute inner central body within the granular general body-mass, the peripheral hyaline and glassy spines, and the very pellucid, extremely slender, filiform, straight, and long pseudopodia.

„ 9. . . A large example of the "Diplophrys-like" organism, having enclosed itself in the middle of an aggregation of frustules of heterogeneous minute diatoms and fragments, along with small fibrous and nondescript shreds, and showing its nearly orbicular, faintly granular body with a large oil-like globule therein. [All the figures × 400.]

PLATE XIII.

FIG. 10. . . A small example of the "Diplophrys-like" organism (considerably more minute than Fig. 9.), the surrounding aggregation of foreign bodies containing no diatomaceous elements, but made up of rather short somewhat hyaline arenaceous and nondescript granules.

" 11. . . *Plagiophrys sphærica* (Clap. et Lachm.) (?) living, seen in profile, and showing its little tree-like cluster of slender branched pseudopodia, emanating from a hollow or depression at one side, which latter presents a number of more or less evident alternate creases and rounded prominences, seemingly due to the mode of infolding at this place of the closely-investing outer integument or "test." The specimen has incepted an example of *Cosmarium cucurbita*.

" 12. . . Another example of the same, treated with acetic acid, showing the "nucleus" ejected, the body-mass retracted from the outer integument, which at the frontal or anterior, formerly infolded, portion, presents a generally broadly conical shape, but characterised by annular ridges, giving a zigzag lateral outline.

" 13. . . An example of the same after treatment in the carmine fluid, showing the elliptic "nucleus" highly dyed, the body-mass not retracted, and the frontal or anterior portion of the integument (or "test"), formerly infolded, now pushed outwards in a broadly-conical shape, with a straight outline.

" 14. . . An example of another form, probably provisionally referrible to the same species, viewed "dorsally," and presenting a dark, very shiny exterior, and very long, branched, and sometimes inosculating granuliferous pseudopodia.

" 15. . . Outline of the contracted and crumpled appearance at once assumed by an example of the foregoing on being treated with the carmine fluid.

" 16. . . Balloon-shaped figure, quickly assumed by an example of the same under the action of the carmine fluid, the creases and wrinkles (indicated by previous figures) being obliterated; the elliptic "nucleus" highly dyed, and the sarcode-body retracted from the integument and partially ejected through the anterior opening in the formerly infolded, now prolonged, truncate neck-like portion caused by its evagination. [All the figures × 400.]

XV.—LABORATORY NOTES. By CHARLES R. C. TICHBORNE, F. C. S., M. R. I. A., &c.

[Read January 9, 1871.]

IN the course of the practical working of a laboratory, and in the prosecution of original research, we frequently make observations, which although not elaborate enough to give rise to voluminous treatises are yet too valuable to be thrown aside into some obscure corner of a chemist's note-book. The following short notes will, I think, be found to consist of original matter which it would be desirable to place on record.

1. *On the Production of Acetic Acid from the Destructive Distillation of Resin.*

On submitting resin to destructive distillation, amongst other products is an aqueous solution possessing strongly acid properties and a very powerful empyreumatic odour. A specimen of this fluid was neutralized with carbonate of sodium, evaporated to dryness, and fused to get rid of colouring matter and volatile impurities. The residue was then dissolved and crystallized twice, by which means beautifully clear and apparently pure crystals were obtained. This sodium salt gave, in solution, a red coloration with ferric chloride, and a white crystalline precipitate with nitrate of silver; when decomposed in the presence of alcohol by sulphuric acid it gave the well known odour of acetate of ethyl.

The precipitate got on adding nitrate of silver, when purified by washing and re-solution, gave on ignition ·913 gramme of silver from 1·413 gramme of the silver salt used. This acid is therefore acetic.*

$$\text{Theory} \quad \frac{\text{Ag. } 1{\cdot}413}{C_2\,H_3\,Ag\,O_2} = {\cdot}9137 \qquad \text{Practice} \quad {\cdot}913$$

It is rather surprising to see acetic acid produced in appreciable quantities from a substance so comparatively poor in oxygen—particularly as oxygenated oils also constitute a comparatively large percentage of the products of destructive distillation. The relative amounts of oxygen in colophony and in an acid-yielding substance differ considerably —e. g.

Colophony	$C_{20}\,H_{30}\,O_2$	Cellulose	$C_6\,H_{10}\,O_5$
Oxygen per cent.	10·6		49·4

The amount of water which comes over in the destructive distillation of resin is not large, but what there is, is very rich in acetic acid; 85 parts of resin give about 74 of liquid products—about two parts of which constitute the aqueous portion. This latter has a specific gravity of 1·018 at 15° C., and estimated with a volumetric solution of soda it was found to contain 11·8 per cent. of the hydrated acid. Perfectly clear and transparent resin, when powdered and dried over sulphuric acid, lost ·43 per cent.—1·389 gramme, after drying, weighing 1·383, whilst opaque pieces lost much more. It is therefore probable that a portion of the aqueous fluid was due to moisture preexisting in the resin.

2. *On the Production of Ozone by Resin Oils.*

When the light oils of resin are submitted to the combined action of atmospheric oxygen and light, all the phenomena indicative of the

* Dr. Thomas Anderson observed that the most volatile fraction of the resin oils contained a trace of what appeared to be acetic acid. The above note will account for its presence there.

presence of ozone are produced in a most striking manner. Cork is rapidly bleached and corroded, and an old specimen of the oils, when poured upon a solution of starch and iodide of potassium, instantly produces blue iodide of starch. Concurrent with the development of ozone is a rise in the boiling point of the fluid. A similar action takes place when resin spirit is excluded from direct sunlight, but the molecular condensation is much slower. The action of atmospheric oxygen as regards the production of ozone seems much more decided in the presence of resin spirit than with turpentine.

Paper moistened with a solution of iodide of potassium and starch, and suspended in a vessel containing resin oils, becomes blued in a few hours. After prolonged exposure the oils exhibit a faint acid reaction. Immediately after washing with a weak solution of carbonate of sodium and distilled water, light resin oil does not produce a change, but on standing for an hour, or so, it becomes charged again with ozone and blues the test-solution.

Ozone is probably the prime mover in the production of colophonic hydrate, described by the author in the Transactions of the Academy.* Dr. Anderson got some substance which he thought was colophonic hydrate in the *recent* products of the destructive distillation of resin. Supposing that it was formed during the process of distillation it would not be found in the oils, simply from the fact that this substance (colophonic hydrate) is very soluble in water—and that as there is an aqueous portion of the product of destructive distillation it is there we must look for it. The author has examined the aqueous products obtained from the distillation of 4¼ tons of resin in one operation. It was perfectly free from colophonic hydrate, which, if it had been formed at all, had evidently been destroyed by the action of the acetic acid which constitutes about 11 per cent. of this fluid.

I have frequently looked for, but could never discover colophonic hydrate in the newly formed hydrocarbons. It simply seems to be produced by the action of atmospheric oxygen, which in the first stage is converted into ozone.

XVI.—On the Cause of the Interrupted Spectra of Gases. By G. Johnstone Stoney, M. A., F. R. S., &c. [Abstract.]

[Read January 9, 1871.]

In the "Philosophical Magazine" for August, 1868, there is a paper on the Internal Motions of Gases,† by the author of the present communication, in which a comparison is instituted between these motions and the phenomena of light, from which the conclusion is drawn that the lines in the spectra of gases are to be referred to periodic motions

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* Transactions, vol. xxiv., Science, p. 579.

† In reading that paper, the reader is requested to correct 16^2 into $\sqrt{16}$, at the end of paragraph 2.

within the individual molecules, and not to the irregular journeys of the molecules amongst one another.

Mr. Stoney thought it possible now to advance another step in this inquiry, and in the present communication he gave an account to the Academy of the grounds upon which he founded this hope.

A *pendulous* vibration, according to the meaning which has been given to that phrase by Helmholtz, is such a vibration as is executed by the simple cycloidal pendulum. It is, accordingly, one in which the relation between the displacement of each particle and the time is represented by the simple curve of sines, of which the equation is

$$y = C_0 + C_1 \sin (x + a),$$

where $y - C_0$ is the displacement of the particle from its central position; C_1 is the amplitude of the vibration; x stands for $2\pi \frac{t}{\tau}$, where t is the time from a fixed epoch, and τ the period of a complete double vibration; and a is a constant depending on the phase of the vibration at the instant which is taken as the epoch from which t is measured.

Now we may not assume that the waves impressed on the æther by one of the periodic motions within a molecule of a gas are of this simple character. We must expect them to be usually much more involved. And whatever may happen to be the intricacy of their form near to their origin, they will retain, substantially, the same complex character so long as they advance through the open undispersing æther, in which waves of all lengths travel at the same rate. But it would seem that a very different state of things must arise when the undulation enters a dispersing medium, such as glass.

Let us suppose that the undulation* before it enters the glass consists of plane waves. Then, whatever the form of these waves, the relation between the displacement of an element of the æther and the time, may be represented by some curve repeated over and over again. This curve may be either one continuous curve, or parts of several different curves joined on to one another. In the latter case (which includes the other) one of the sections of the curve may be represented by the equations

$$\left.\begin{array}{l} y = \phi_0 (x) \text{ from } x = o \text{ to } x = x_1, \\ y = \phi_1 (x) \text{ from } x = x_1 \text{ to } x = x_2, \\ \qquad \text{and so on, to} \\ y = \phi_1 (x) \text{ from } x = x_1 \text{ to } x = 2\pi \end{array}\right\} \qquad (1)$$

y being the displacement, and x being an abbreviation for $2\pi \frac{t}{\tau}$ where τ is the complete periodic time of one wave.

The undulation in vacuo will then be represented, according to Fourier's well-known theorem, by the following series:

$$\left.\begin{array}{l} y = A_0 + A_1 \cos x + A_2 \cos 2x + \ldots \\ \qquad + B_1 \sin x + B_2 \sin 2x + \ldots \end{array}\right\} \qquad (2)$$

* By the term *undulation* is to be understood a series of waves.

where the coefficients are obtained from equations (1) by the definite integrals.

$$\begin{aligned} \int_0^{2\pi} y \cos nx,\ dx &= \pi A_n. \\ \int_0^{2\pi} y \sin nx,\ dx &= \pi B_n. \end{aligned} \qquad (3)$$

Equation (2), the equation of the undulation before it enters the glass, may be put into the more convenient form

$$y - A_0 = C_1 \sin (x + a_1) + C_2 \sin (2x + a_2) + \ldots \qquad (4)$$

where $y - A_0$ is the displacement from the position of rest, and the new constants are related to those of equ. (2) as follows:

$$C_n = \sqrt{A_n^2 + B_n^2},\quad a_n = \tan^{-1}, \frac{A_n}{B_n}. \qquad (5)$$

The first term of expansion (4) represents a pendulous vibration of the full period τ: the remaining terms represent harmonics of this vibration, i. e. their periodic times are $\frac{1}{2}\tau$, $\frac{1}{3}\tau$, &c. All of these also are pendulous, so that equ. (4) is equivalent to the statement that whatever be the form of the plane undulation before entering the glass, it may be regarded as formed by the superposition of a number of simple pendulous vibrations, one of which has the full periodic time τ, while the others are harmonics of this vibration.

Moreover, these vibrations will co-exist in a state of mechanical independence of one another, if the disturbance be not too violent for the legitimate employment of the principle of the superposition of small motions. So long as the light traverses undispersing space these constituent vibrations will strictly accompany one another, since in open space waves of all periods travel at the same velocity. The general resulting undulation will, therefore, here retain whatever complicated form it may have had at first. But when the undulation enters such a medium as glass, in which waves of different periods travel at different rates, the constituent vibrations are no longer able to keep together, each being forced to advance through the glass at a speed depending on its periodic time. Thus, there arises a physical resolution within the glass of series (4) into its constituent terms.* And if the

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* Other expansions similar to Fourier's series can be conceived, in which the terms, instead of representing pendulous vibrations, should represent vibrations of any other prescribed form; and hence, a doubt may arise whether the physical resolution effected by the prism is into the terms of the simpler series. That it is so may, perhaps, not be susceptible of demonstration; but the following considerations seem to show it to be probable in so high a degree that it is the hypothesis which we ought, provisionally, to accept. For, firstly, the form of the emerging vibrations is independent of the material of the prism, since the lines correspond to the same wave-lengths as seen in all prisms; and, secondly, it is independent of the amplitude of the vibration within very wide limits, since the positions of the lines remain fixed through great ranges of temperature, and, in many cases, when the temperature falls so low that the lines fade out through excessive faintness.

glass be in the form of a prism the pendulous undulations corresponding to the successive terms of series (4), will emerge in different directions, so that each will give rise to a separate line in the spectrum of the gas.

We thus find that one periodic motion in the molecules of the incandescent gas may be the source of a whole series of lines in the spectrum of the gas. The n^{th} of these lines is represented by the term

$$C_n \sin (n x + a_n),$$

in which C_n is the amplitude of the vibration, and, consequently, C_n^2 represents the brightness of the line. If some of the coefficients of series (4) vanish, the corresponding lines are absent from the spectrum. This is analogous to the familiar case of the suppression of some of the harmonics in music, and appears to be what usually occurs in those spectra which are called by Plucker, spectra of the Second Order.

In spectra of this kind the lines which fall within the limits of the visible spectrum appear, at first sight, to be scattered at irregular intervals. This may arise, and probably does in most cases arise in part, from the circumstance that there may be several distinct motions in each molecule of the gas, each of which produces its own series of harmonics in the spectrum, which by their being presented together to the eye give the appearance of a confused maze of lines. But it appears also to arise in part from the absence of most of the harmonics, so that it is not easy to trace the relationship between the few that remain. To do so, without the assistance of spectra of the First Order, requires that we should have at our disposal determinations of the wave-lengths of the lines, made with extraordinary accuracy; and perhaps, in a few cases, as, for example, in the case of Hydrogen, the marvellous determinations which have been made by Ångström, may have the requisite precision.

The ordinary spectrum of Hydrogen consists of four lines corresponding to C in the solar spectrum, F, a line near G, and h. To these it is possible that we ought to add a conspicuous line in the solar prominences, which lies near D, but which has not yet been found in the artificial spectrum of Hydrogen. Of these lines, three, viz.: C, F, and h, are to be referred to the same motion in the molecules of the gas.

In fact, the wave-lengths of these lines, as determined by Ångström,* are—

$$h = 4101 \cdot 2 \text{ tenth-metres.}$$
$$F = 4860 \cdot 74 \quad ,,$$
$$C = 6562 \cdot 10 \quad ,,$$

These are their wave-lengths in air of standard pressure, and 14° temperature, determined with extraordinary precision. We must correct these for the dispersion of the air, so as to arrive at the wave-

* Ångström's "Recherches sur le Spectre Solaire," p. 31. A tenth-metre means metre divided by 10^{10} similarly a fourteenth-second is a second of time divided by

lengths in vacuo, which are proportionate to the periodic times. Now, by interpolating between Ketteler's observations* on the dispersion of air, we find—

$$\mu_h = 1{\cdot}000\ 29952$$
$$\mu_F = 1{\cdot}000\ 29685$$
$$\mu_C = 1{\cdot}000\ 29383$$

for the refractive indices of air of standard pressure and temperature for the rays *h*, *F*, and *C*. From these we deduce that if the air be at 14° of temperature, the refractive indices will become

$$\mu_h = 1{\cdot}000\ 2845$$
$$\mu_F = 1{\cdot}000\ 2820$$
$$\mu_C = 1{\cdot}000\ 2791$$

Multiplying the foregoing wave-lengths by these values we find for the wave-lengths in vacuo,

$$h = 4102{\cdot}37,$$
$$F = 4862{\cdot}11,$$
$$C = 6563{\cdot}93,$$

which are the 32nd, 27th, and 20th harmonics of a fundamental vibration, whose wave-length in vacuo is

0·13127714 of a millimetre,

as appears from the following table:—

Observed wave-lengths reduced to wave-lengths in vacuo.	Calculated values.	Differences.
Xth-metres.	Xth-metres.	Xth-metres.
$h = 4102{\cdot}37$	$\frac{1}{32} \times 131277{\cdot}14 = 4102{\cdot}41$	$+0{\cdot}04$
$F = 4862{\cdot}11$	$\frac{1}{27} \times 131277{\cdot}14 = 4862{\cdot}12$	$+0{\cdot}01$
$C = 6563{\cdot}93$	$\frac{1}{20} \times 131277{\cdot}14 = 6563{\cdot}86$	$-0{\cdot}07$

Thus, the outstanding differences are all fractions of an eleventh-metre, an eleventh-metre being the limit within which Ångström thinks that his measures may be depended on.

The wave-length 0·13127714 of a millimetre corresponds to the periodic time 4·4 fourteenth-seconds, if we assume the velocity of light to be 298,000,000 metres per second.

Hence, we may conclude, with a good deal of confidence, that 4·4 XIVth-seconds, is very nearly the periodic time of one of the motions within the molecules of Hydrogen.

The other harmonics of this fundamental motion in the molecules of Hydrogen, viz.: the 19th, 21st, 22nd, &c., harmonics, are not found

* "Philosophical Magazine," Part II. for 1866, p. 345.

in this spectrum of Hydrogen. But two other spectra of Hydrogen are known to exist, in which there are a great number of lines; and possibly the missing harmonics will be found amongst them when their positions shall have been sufficiently accurately mapped down. A far more moderate degree of accuracy will suffice in this case than was required by the foregoing investigation.

But it is from the examination of spectra of the First Order that the most copious results may be expected. These spectra consist of lines ruled close to one another, and presenting in the aggregate the appearance of patterns which often resemble the flutings on a pillar. When these spectra are more carefully examined it is probable that the whole series of lines, occasioning one of the fluted patterns, will be found to be the successive harmonics of a single motion in the molecules of the gas. It may readily be shown that such patterns as are met with in nature may in this way arise. For this purpose it is only necessary to make some suitable hypothesis as to the original undulation impressed by the gas upon the æther. Thus, if the law of this undulation were the same as that of the motion of a point near the end of a violin string, and of a periodic time sufficiently long, as for example, two million-millionths of a second, this undulation, when analysed by the prism, would give a spectrum covered with lines, ruled at intervals about the same as that between the two *D* lines, and of intensities varying so as to become gradually brighter and then gradually fainter several times in succession in passing from line to line along the spectrum. These alternations would give a fluted appearance to the spectrum; and from appropriate hypotheses as to the original vibration all the patterns met with in nature would result. Possibly, it may prove to be practicable to trace back from the appearances presented within the limits of the visible spectrum to the character of the original motion, to which they are all to be referred. But, however this may be, it will be easy in a spectrum of this kind, in which we have a long series of consecutive harmonics, to determine, at least, the period of this motion—and it is in the examination of these spectra that the most easily-obtained results may be expected. But the necessary observations are, at present, almost altogether wanting. The only case in which the author had been able to arrive at any result has been in the case of the Nitrogen spectrum of the First Order, observed by Plücker. It would appear from his observations* that the more refrangible of the two fluted patterns observed by him is due to a motion in the gas having a wave-length of about 0·89376 of a millimetre, which corresponds to a periodic time of 3 XIIth-seconds: one of the flutings consisting of the thirty-five harmonics from about the 1960th to the 1995th.

This result, however, does not command the confidence which the preceding determination of one of the periodic times in Hydrogen does; but it will suffice to show the character of the much easier investigation which has to be made in the case of gases which produce spectra of the First Order.

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* "Philosophical Transactions" for 1865, p. 7, s. 16.

XVII.—AN ACCOUNT OF EXPERIMENTS UPON THE MOTION OF VORTEX RINGS IN AIR. By Professor R. S. BALL. [Abstract.]

[Read 23 January, 1871.]

THE problem discussed was the following:—A vortex ring projected with a certain initial velocity is gradually retarded by the air; according to what law does the resisting force act? The rings were formed by the falling of a pendulum from a given height upon a 2′ cube box of the usual construction. The ring was made to impinge upon a target placed at different distances. The time intervening between the release of the pendulum and the blow of the ring on the target was measured by Wheatstone's chronoscope. Making proper allowance for the time of descent of the pendulum, the time occupied by the ring in travelling a certain distance was measured to the hundredth part of a second. The range of the ring, to which the experiments refer, was from a distance of four feet from the front of the box when the ring was moving with a velocity of 10·2 feet per second to a distance of 20 feet, when the velocity was reduced to 4·3 feet per second.

From a discussion of the results it appears that the observations can be accounted for on the supposition that the retarding force varies directly as the velocity of the ring, the space (s), the time (t), and the velocity (v), being connected by the following equations:

$$s = 27{\cdot}7\ (1 - (0{\cdot}69)^t)$$

$$v = \frac{ds}{dt} = 10{\cdot}2\ (0{\cdot}69)^t$$

$$\frac{d^2s}{dt^2} = -\ 0{\cdot}37v.$$

Tables embodying the methods of reduction employed accompanied the paper.

XVIII.—ON RESULTS OBTAINED BY THE AGOSTA EXPEDITION TO OBSERVE THE RECENT SOLAR ECLIPSE. By CHARLES E. BURTON, ESQ.

[Read February 13, 1871.]

AGOSTA is a small town twenty miles north of Syracuse, on the east coast of Sicily. The station occupied by our party, and which formed the most western observatory, was immediately to the south of that of the Italian astronomers, and overhanging the sea, below the fortress. The instruments used were as follows, taking them in order from west to east: by Professor *W. G. Adams*, of King's College, a biquartz on

a telescope of 2 inches aperture, besides a modified Savart's polariscope of great sensibility, but having a small field, not telescopic; *Mr. Clifford* had a biquartz also, I believe, on a telescope; *Mr. Ranyard*, who was stationed at Villasmonda, seven miles west of Agosta, at an elevation of about 600 feet above the sea, had a 2·75-inch or 3-inch achromatic, fitted with a biquartz, the finder having a quartz plate as a cap. The Author had Mr. Buckingham's equatorial achromatic, with a 5-inch object glass, fitted with a Herschel-Browning direct vision spectroscope with two prisms, whose dispersion was equal to 1½ times that of a flint glass prism of 60°. This instrument showed the line D double, and also the close pair of the group *b*. There was no driving clock.

Preliminary experiments were made on the morning of the 22nd, to test the capability of the instrument for detecting protuberances, the slit being set to such a width as would permit distinct vision of some 60 Frauenhofer lines—the intention being to get as much light as possible, consistently with allowing the detection of dark lines in the corona spectrum—supposing that they co-existed with sufficient intrinsic brilliancy. The protuberances were readily caught with a tangential slit, the forms even of some of them being rendered visible by a rapid vibration imparted to the instrument. The principal protuberances were mapped for my own use and that of others who wished to know their position. It was of course, desirable, as far as possible to avoid them, and thus to get the pure spectrum of the corona. It was found that the E. and W. points of the sun's limb were very free from protuberances. Accordingly the following plan of operations during totality was determined upon.

The slit was set north and south, i. e. in a circle of declination, and the four points of the sun's disc, E., W., N., and S., were fixed upon to be examined in succession with the slit, the direction of which, referred to any great circle, was to be retained constant during the observations. My assistant at the finder, Sergeant Ring, R. E., was instructed at the moment of commencement of totality to point the instrument on the corona immediately outside the E. point of the moon's limb. When that region had been observed, he was to point similarly at a place immediately exterior to the W. limb, then we were to proceed to the north, and end our pre-determined work at the south point of the limb.

By this method of working, we hoped to obtain with the slit tangential at E. and W. limbs, the spectrum of the lower regions of the corona. Then, the radial slit at N. and S. would enable me to compare the spectra of the upper and lower regions, which would be visible in the same field, the visible length of the slit being nearly 8′ of arc.

After this, if there was time still remaining, we hoped to secure the spectrum of any other part which should seem brightest to the Sergeant at the finder.

It should here be remarked, that the finder was non-inverting, being an ordinary pocket spy-glass, kindly lent by the Colonel in

command of the Sappers stationed at Agosta. The telescope had been sent out without a finder or declination clamp, and both these wants had to be supplied on the spot.

I occupied myself, in part, during the early stages of the eclipse, in correcting the relative adjustments of the finder and telescope, on the horns of the dying solar crescent, which were admirably adapted for the purpose.

About two minutes before the totality,* while engaged in this operation at the southern horn,. moving the instrument to and fro in right ascension only, I believe, I was astounded to observe that the ordinary chromosphere lines had received an enormous addition to their number, there being at least twenty-five lines visible between the exterior line of the group *b* and *D*. Two of the magnesium lines, at least, were seen reversed. I began to count, but a remark from the Sergeant that he could see the protuberance—at or near which I was looking—in the finder through his sunshade, which was compounded of a red and blue glass superposed, warned me that I must set on the point first to be observed during totality. Accordingly, after an instant's glance through the finder with the unused eye, I sat down again at the spectroscope to wait during the few remaining seconds of sunshine.

The lines above mentioned were all bent toward the less refrangible end of the spectrum, and the longest, the hydrogen lines, were branched at the extremities furthest from the moon's limb, presenting a tree-like form. The new lines were simply bent without being much, if at all, branched. This, of course, indicated a violent rushing of the middle and upper portions of the mass of hydrogen under examination away from the observer, the deflection being greater than the extreme breadth of the slit. The observations, so far as they go, appear to me strongly in favour of the theory of the distribution of the gases and vapours of the sun's atmosphere, ably advocated by Mr. Stoney.

The first few seconds of totality were lost on account of my eye not having become accustomed to the darkness of the field, but upon taking precautions to shut out the glare of the southern horizon, which was very strong, I perceived towards the left hand side of the field of view a faint positive† line which seemed to rise out of a faint continuous spectrum as a background. The eyepiece of the spectroscope had been fitted with a sort of comb which was intended to serve as a means of referring the bright lines which might become visible during totality to their proper place in the solar spectrum, but the unexpected darkness of the field prevented the determination being made in this way.

Thus, I was forced to compare the place in the field of the positive line just mentioned with the place of the E line recollected from the observations made a few seconds before. I had devoted several hours on

* I am not quite certain of the order in time here.

† The word *positive* is here used to distinguish the line, which was by no means bright, from the negative or absorption lines, which were being looked for at the same time.

that day, and on previous days, to the study of the solar spectrum, as seen in the instrument I was using, so that I considered myself justified in putting on record my estimate of the refrangibility of the line in the corona as being decidedly less than the refrangibility of E. Only for a few seconds was this remarkable spectrum seen, for a small cloud, which had begun to form to the west of the sun before totality, passing towards the east, and growing as it passed, shut out our view, the line fading steadily till I could no longer see it.

On hearing from Sergeant Ring the state of the case, I looked up at the place of the sun: nothing was visible save the drifting cloud, and above it a brilliant star, which proved to be the planet Venus.

As the end of totality drew near the little cloud passed rapidly off, and for a few seconds I saw the western side of the corona as a pearl white half circle, without rays, about 30′ or 35′ broad. The Sergeant was at once ordered to set on the west limb of the moon. While he was doing so a brilliant bead like a star appeared nearly at the W. point and increased with immense rapidity; the totality was passed, and nothing could now be done but the jotting down of the results of my labours, few and imperfect enough. The report of what I had seen was written down at once, before holding communication with any one.

The sketching department was chiefly entrusted to Mr. John Brett, a gentleman who, happily, unites the peculiar qualifications of an astronomical observer with artistic powers of no mean order. It was fortunate that he had, not long before proceeding to join the Eclipse Expedition, furnished himself with a powerful reflector mounted so as to be peculiarly adapted for observations of the sun, the upper half of the tube being left open, an arrangement which almost entirely does away with tube currents of unequally heated air. As to the quality of the instrument, a few words will suffice, namely, that the mirror was an 8½-inch With-Browning, the eyepieces Browning's achromatic, and the sun apparatus a Herschel prism with a neutral tint dark wedge.

The atmospheric circumstances on the morning of the 22nd were unusually magnificent, the details of the solar surface and spots being beautifully defined and steady.

About twenty minutes after first contact, Mr. Brett requested me to come to his telescope as he had detected a prolongation of the moon's limb beyond the cusps of the solar crescent. On examining the distribution of light beyond the sun's image, both on and off the moon, it was very striking to see how very much more intense the faint extension of light from the solar limb proper was than the extremely feeble luminosity which overspread the encroaching limb of the moon. Here was an observation of the corona in what was practically broad daylight, showing that if we had some means of producing the necessary contrast, the corona might be observed distinct from the general illumination of our own atmosphere on any really *clear* day.

After all was over Mr. Brett made the remark that the appearance

of projection had been even more distinctly visible during the partial phases succeeding totality.

These observations have been generally confirmed by Professor Watson, Director of the Ann Arbor Observatory, United States, with a 4-in. Alvan Clarke refractor.

I noticed further that the limb of the sun was slightly tinged with tawny brown (rather yellowish) to a distance inwards of about 1′, no colour being perceptible along the contour of the moon, which was then about half-way on the face of the sun.

It may be noticed, in addition, that Messrs. Brett and Watson paid particular attention to the mode of formation of the Baily Beads, which were seen to be due solely to the interruption of the contour of the sun by the tops of the lunar mountains.

Mr. Brett watched carefully for any traces of a lunar atmosphere, as evidenced by the blunting of the solar cusps or change of figure of details of spots while undergoing occultation, but he reports that there was no trace of either phenomenon, the cusps, especially, appearing as sharp as needles. I am happy to be able to record my entire concurrence in the second of these observations, but, as to the first point, the sharpness of the cusps, I am compelled to say that at no time *while I was observing* with Mr. Brett's instrument did they appear absolutely sharp, the points seeming always to be slightly and very slightly blunted. This is not necessarily to be taken as evidence in favour of a lunar atmosphere, for the roughness of the limb would tend to prevent perfect sharpness of the horns of the crescent.

XIX.—NOTE ON EOZOON CANADENSE. [In reply to Professors KING and ROWNEY.] By J. W. DAWSON, LL. D., F. R. S., Principal of M'Gill College, Montreal.

[Read Febuary 13, 1871.]

THROUGH the kindness of the authors, I received last summer a copy of a paper on the fossil above named, contributed to the Royal Irish Academy by Professors King and Rowney, and reiterating their already often refuted objections to its animal nature. Though reluctant to waste in controversy time of which I have much too little at my disposal for the many subjects of original investigation open to me in this country, I think it necessary, in the interest of truth, to ask permission to place on record, in the "Proceedings" of the Society which has published Professors King and Rowney's Paper, some of my reasons for dissenting from their conclusions, and some of my objections to their mode of treating the subject; referring, however, to my former reply contained in the Journal of the Geological Society of London, for August, 1867.

1. I object to their mode of stating the question at issue, whereby they convey to the reader the impression that this is merely to account for the occurrence of certain peculiar forms in Ophite.

With reference to this it is to be observed that the attention of Sir William Logan, and of the writer, was first called to Eozoon, by the

occurrence in Laurentian rocks of definite forms resembling the Silurian *Stromatopora*, and dissimilar from any concretions or crystalline structures found in these rocks. With his usual sagacity, Sir William added to these facts the consideration that the mineral substances occurring in these forms were so dissimilar as to suggest that the forms themselves must be due to some extraneous cause rather than to any crystalline or segregative tendency of their constituent minerals. These specimens, which were exhibited by Sir William, as probably fossils, at the meeting of the American Association in 1859, and noticed with figures in the Report of the Canadian Survey for 1863, showed under the microscope no minute structures. The writer, who had at the time an opportunity of examining them, stated his belief that if fossils, they would prove to be not Corals but Protozoa.

In 1864, additional specimens having been obtained by the Survey, slices were submitted to the writer, in which he at once detected a well-marked canal-system, and stated, decidedly, his belief that the forms were organic and foraminiferal. The announcement of this discovery was first made by Sir W. E. Logan, in Silliman's Journal for 1864. So far, the facts obtained and stated related to definite forms mineralized by loganite, serpentine, pyroxene, dolomite, and calcite. But before publishing these facts in detail, extensive series of sections of all the Laurentian limestones, and of those of the altered Quebec group of the Green Mountain range, were made, under the direction of Sir W. E. Logan and Dr. Hunt, and examined microscopically. Specimens were also decalcified by acids, and subjected to chemical examination by Dr. Sterry Hunt. The result was the conviction that the definite laminated forms must be organic, and farther, that there exist in the Laurentian limestones fragments of such forms retaining their structure, and also other fragments, probably organic, but distinct from Eozoon. These conclusions were submitted to the Geological Society of London, in 1864, after the specimens on which they were based had been shown to Dr. Carpenter and Professor T. R. Jones, the former of whom detected in some of the specimens an additional foraminiferal structure—that of the tubulation of the proper wall, which I had not been able to make out. Subsequently, in rocks at Tudor, of somewhat later age than those of the Lower Laurentian at Grenville, similar structures were found in limestones not more metamorphic than many of those which retain fossils in the Silurian system. I make this historical statement in order to place the question in its true light, and to show that it relates to the organic origin of certain definite mineral masses, exhibiting not only the external forms of fossils, but also, their internal structure.

In opposition to these facts, and to the careful deductions drawn from them, the authors of the Paper under consideration maintain that the structures are mineral and crystalline. I believe that in the present state of science such an attempt to return to the doctrine of "plastic-force" as a mode of accounting for fossils would not be tolerated for a moment, were it not for the great antiquity and highly crystalline condition of the rocks in which the structures are found,

which naturally create a prejudice against the idea of their being fossiliferous. That the authors themselves feel this is apparent from the slight manner in which they state the leading facts above given, and from their evident anxiety to restrict the question to the mode of occurrence of serpentine in limestone, and to ignore the specimens of Eozoon preserved under different mineral conditions.

2. With reference to the general form of Eozoon and its structure on the large scale, I would call attention to two admissions of the authors of the Paper, which appear to me to be fatal to their case:—First, they admit, at page 533 [Proceedings, vol. x.], their "inability to explain satisfactorily" the alternating layers of carbonate of lime and other minerals in the typical specimens of Canadian Eozoon. They make a feeble attempt to establish an analogy between this and certain concentric concretionary layers; but the cases are clearly not parallel, and the laminæ of the Canadian Eozoon present connecting plates and columns not explicable on any concretionary hypothesis. If, however, they are unable to explain the lamellar structure alone, as it appeared to Logan in 1859, is it not rash to attempt to explain it away now, when certain minute internal structures, corresponding to what might have been expected on the hypothesis of its organic origin, are added to it? If I affirm that a certain mass is the trunk of a fossil tree, and another asserts that it is a concretion, but professes to be unable to account for its form and its rings of growth, surely his case becomes very weak after I have made a slice of it, and have shown that it retains the structure of wood.

Next, they appear to admit that if specimens occur wholly composed of carbonate of lime their theory will fall to the ground. Now such specimens do exist. They treat the Tudor specimen with scepticism as probably "strings of segregated calcite." Since the account of that specimen was published, additional fragments have been collected, so that new slices have been prepared. I have examined these with care, and am prepared to affirm that the chambers in these specimens are filled with a dark-coloured limestone not more crystalline than is usual in the Silurian rocks, and that the chamber-walls are composed of carbonate of lime, with the canals filled with the same material, except where the limestone filling the chambers has penetrated into parts of the larger ones. I should add that the stratigraphical researches of Mr. Vennor, of the Canadian Survey, have rendered it probable that the beds containing these fossils, though unconformably underlying the Lower Silurian, overlie the Lower Laurentian of the locality, and are, therefore, probably Upper Laurentian, or perhaps Huronian, so that the Tudor specimens may approach in age to Gümbel's Eozoon Bavaricum.*

* Dr. Hunt, in a recent communication to the "American Journal of Science" for July, 1870, p. 85, is disposed to regard them as belonging to a great series of strata not hitherto clearly recognised, lying at the base of the Primordial, but distinct from and newer than the Upper Laurentian and the Huronian.

Farther, the authors of the Paper have no right to object to our regarding the laminated specimens as "typical" Eozoon. If the question were as to *typical ophite* the case would be different; but the question actually is as to certain well-defined forms which we regard as fossils, and allege to have organic structure on the small scale, as well as lamination on the large scale. We profess to account for the acervuline forms by the irregular growth at the surface of the organisms, and by the breaking of them into fragments confusedly intermingled in great thicknesses of limestone, just as fragments of corals occur in Palaeozoic limestone; but we are under no obligation to accept irregular or disintegrated specimens as typical; and, when objectors reason from these fragments, we have a right to point to the more perfect examples. It would be easy to explain the loose cells of *Tetradium* which characterize the Birds-eye limestone of the Lower Siluran of America, as crystalline structures; but a comparison with the unbroken masses of the same coral, shows their true nature. I have for some time made the minute structure of Palaeozoic limestones a special study, and have described some of them in the Trenton formation of Canada. I propose, shortly, to publish additional examples, showing fragments of various kinds of fossils preserved in these limestones, and recognizable only by the infiltration of their pores and other minute structures. I shall also be able to show that in many cases the crystallization of the carbonate of lime and the infiltration of other substances have not interfered with the perfection of the most minute of these structures.

The fact that the chambers are usually filled with silicates is strangely regarded by the authors as an argument against the organic nature of Eozoon. One would think that the extreme frequency of silicious fillings of the cavities of fossils, and even of silicious replacement of their tissues, should have prevented the use of such an argument, without taking into account the opposite conclusions to be drawn from the various kinds of silicates found in the specimens, and from the modern filling of Foraminifera by hydrous silicates, as shown by Ehrenberg, Mantell, Carpenter, Bailey, and Pourtales.* Farther, I have elsewhere shown that the loganite is proved by its texture to have been a fragmental substance, or at least filled with loose *debris;* that the Tudor specimens have the cavities filled with a sedimentary limestone, and that several fragmental specimens from Madoc are actually wholly calcareous. It is to be observed, however, that the wholly calcareous specimens present great difficulties to an observer; and I have no doubt that they are usually overlooked by collectors in consequence of their not being developed by weathering, or showing any obvious structure in fresh fractures.

3. With regard to the canal system, the authors persist in confusing the casts of it which occur in serpentine with "metaxite" concretions, and in likening them to dendritic crystallizations of silver, &c., and

* "Quarterly Journal Geol. Society," 1864.

coralloidal forms of carbonate of lime. In answer to this, I think it quite sufficient to say that I fail to perceive the resemblance as other than very imperfectly imitative. I may add, that the case is one of the occurrence of a canal structure in forms which on other grounds appear to be organic, while the concretionary forms referred to are produced under diverse conditions, none of them similar to those of which evidence appears in the specimens of Eozoon. With the singular theory of pseudomorphism, by means of which the authors now supplement their previous objections, I leave Dr. Hunt to deal.

4. With regard to the proper wall and its minute tubulation, the essential error of the authors consists in confounding it with fibrous and acicular crystals, and in maintaining that because the tubuli are sometimes apparently confused and confluent they must be inorganic. With regard to the first of these positions, I may repeat what I have stated in former papers—that the true cell-wall presents minute cylindrical processes traversing carbonate of lime, and usually nearly parallel to each other, and often slightly bulbose at the extremity. Fibrous serpentine, on the other hand, appears as angular crystals, closely packed together, while the numerous spicular crystals of silicious minerals which often appear in metamorphic limestones, and may be developed by decalcification, appear as sharp angular needles usually radiating from centres or irregularly disposed. Plate 44, Fig. 10 (Ophite from Skye, King and Rowney's Paper, "Proc. R. I. A.," vol. x.), is an eminent example of this; and whatever the nature of the crystals may be, they have no appearance in the plate of being tubuli of Eozoon. I have very often shown microscopists and geologists the cell-wall along with veins of chrysotile and coatings of acicular crystals occurring in the same or similar limestones, and they have never failed at once to recognize the difference, especially under high powers.

I do not deny that the tubulation is often imperfectly preserved, and that in such cases the casts of the tubuli may appear to be glued together by concretions of mineral matter, or to be broken or imperfect. But this occurs in all fossils, and is familiar to any microscopist examining them. How difficult is it in many cases to detect the minute structure of Nummulites and other fossil Foraminifera? How often does a specimen of fossil wood present in one part distorted and confused fibres or mere crystals, with the remains of the wood forming phragmata between them, when in other parts it may show the most minute structures in perfect preservation? But who would use the disintegrated portions to invalidate the evidence of the parts better preserved? Yet this is precisely the argument of Professors King and Rowney, and which they have not hesitated in using in the case of a fossil so old as Eozoon, and so often compressed, crushed, and partly destroyed by mineralization.

I have in the above remarks confined myself to what I regard as absolutely essential by way of explanation and defence of the organic

nature of Eozoon. It would be unprofitable to enter into the multitude of subordinate points raised by the authors, and their theory of mineral pseudomorphism is discussed by my friend Dr. Hunt; but I must say here that this theory ought, in my opinion, to afford to any chemist a strong presumption against the validity of their objections, especially since it confessedly does not account for all the facts, while requiring a most complicated series of unproved and improbable suppositions.

The only other new features in the communication to which the note refers are contained in the "supplementary note." The first of these relates to the grains of coccolite in the limestone of Aker, in Sweden. Whether or not these are organic, they are obviously different from *Eozoon Canadense.* They, no doubt, resemble the grains referred to by Gümbel as possibly organic, and also similar granular objects with projections which, in a previous Paper, I have described from Laurentian limestones in Canada. These things may be crystalline; but if organic, they are radically distinct from Eozoon. The second relates to the supposed crystals of malacolite from the same place. Admitting the interpretation given of these to be correct, they are no more related to Eozoon than are the curious vermicular crystals of a micaceous mineral which I have noticed in the Canadian limestones.

The third and still more remarkable case is that of a spinel from Amity, New York, containing calcite in its crevices, including a perfect canal system preserved in malacolite. With reference to this, as spinels of large size occur in veins in the Laurentian rocks, I am not prepared to say that it is absolutely impossible that fragments of limestone containing Eozoon may not be occasionally associated with them in their matrix. I confess, however, that until I can examine such specimens, which I have not yet met with, I cannot, after my experience of the tendencies of Messrs. Rowney and King to confound other forms with those of Eozoon, accept their determinations in a matter so critical and in a case so unlikely.

On two points in conclusion it is necessary to say a few words. The first is the geological range of Eozoon. This, at present, is Laurentian, and possibly, even Primordial, according to Dr. Hunt. Similar forms, however, exist in the unaltered Lower Silurian rocks, and are at present included in the genera *Stromatopora*, *Stromatocerium*, and *Archaeocyathus*, along with corals and sponges properly belonging to those genera. I hope at some future time to refer more in detail to these facts which I am now investigating, with reference to the Palaeozoic successors of Eozoon, some of which are very interesting. With regard to the Connemara ophiolites, I regard these as similar to certain more recent ophiolites from the Green Mountain range of the Eastern Townships of Canada, which have not afforded Eozoon, and I have never been able to satisfy myself of the occurrence of any definite organic structure in the Connemara specimens. With regard to the so-called Liassic specimens from Skye, without admitting the Liassic age of the specimens, which, I beg to suggest, is still somewhat doubt-

ful,* I may safely say that the figure at length given by Messrs. Rowney and King of their vaunted specimen does not seem to me to present the characters of Eozoon, but, on the contrary, shows granules of serpentine hispid with acicular crystals, which may be, and probably are, altogether inorganic.

The last point which I shall mention is the taunt that so little further progress has been made in the investigation of Eozoon. With reference to this, I beg leave to doubt whether a process of confounding the actual structure of Eozoon with all manner of dendritic and crystalline forms, in the way followed by the authors, would constitute progress. But in so far as careful comparison with all specimens which have been recently found is concerned, some progress has been made; and I trust that it will soon be possible to bring forward not merely additional specimens illustrative of the structure of Eozoon, but fresh evidence of its wide geographical range, and also links of connexion with fossils of the Palaeozoic rocks. The discovery recently made in Massachusetts, and alluded to by Messrs. Rowney and King, is itself not without importance. In the meantime I am content to accept the investigations of Messrs. King and Rowney as nearly exhaustive of the natural history of those imitative forms which may be confounded with Eozoon, and therefore as in a certain way useful in the further prosecution of the subject. As already stated, I am at this moment engaged in following out, as opportunity offers, two lines of investigation bearing on the following points:—(1) the study of the Lower Silurian and Primordial successors of Eozoon, and (2) that of the tubulation and other structures similar to those of Eozoon preserved in the Palaeozoic rocks.

XX.—MESSRS. KING AND ROWNEY ON EOZOON CANADENSE. By T. STERRY HUNT, LL. D., F. R. S.

[Read February 27, 1870.]

IN the "Proceedings of the Royal Irish Academy," for July 12, 1869, Messrs. King and Rowney have given us at length their latest corrected views on various questions connected with *Eozoon Canadense.* Leaving to my friend, Dr. Dawson, the discussion of the Zoological aspects of the question, I cannot forbear making a few criticisms on the chemical and mineralogical views of the authors. The problem which they had before them was to explain the occurrence of certain forms which, to skilled observers, like Carpenter, Dawson, and Rupert Jones, appear to possess all the structural character of the calcareous skeleton of a foraminiferal organism, and moreover to show how it happens that these forms of crystalline carbonate of lime are associated with serpentine in such a way as to lead these observers to

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* See Dr. Hunt's note on the rocks of Skye, "Am. Jour. Science," for March, 1870, p. 186.

conclude that this hydrous silicate of magnesia filled and enveloped the calcareous skeleton, replacing the perishable sarcode. The hypothesis now put forward by Messrs. King and Rowney to explain the appearances in question, is, that all this curiously arranged serpentine, which appears to be a cast of the interior of a complex foraminiferal organism, has been shaped or sculptured out of plates, prisms, and other solids of serpentine, by "the erosion and incomplete waste of the latter, *the definite shapes* being residual portions of the solid that have not completely disappeared." The calcite which limits these definite shapes, or, in other words, what is regarded as the calcareous skeleton of Eozoon, is a "replacement pseudomorph" of calcite taking the place of the wasted and eroded serpentine. It was not a calcareous fossil, filled and surrounded by the serpentine, but was formed in the midst of the serpentine itself, by a mysterious agency which dissolved away this mineral to form a mould, in which the calcite was cast. This marvellous process can only be paralleled by the operations of that plastic force in virtue of which sea-shells were supposed by some old naturalists to be generated in the midst of rocky strata. Such equivocally formed fossils, whether oyster or foraminifers, may well be termed *pseudomorphs*, but we are at a loss to see with what propriety the authors of this singular hypothesis invoke the doctrines of mineral pseudomorphism, as taught by Rose, Blum, Bischof, and Dana. In replacement pseudomorphs, as understood by these authors, a mineral species disappears and is replaced by another which retains the external form of the first. Could it be shown that the calcite of the cell-wall of Eozoon was once serpentine, this portion of carbonate of lime would be a replacement pseudomorph after serpentine; but why the portions of this mineral, which in the hypothesis of Messrs. King and Rowney have been thus replaced, should assume the forms of a foraminiferal skeleton, is precisely what our authors fail to show, and, as all must see, is the gist of the whole matter.

Messrs. King and Rowney, it will be observed, assume the existence of calcite as a replacement pseudomorph after serpentine, but give no evidence of the possibility of such pseudomorphs. Both Rose and Bischof regard serpentine itself as, in all cases, of pseudomorphous origin, and as the last result of the changes of a number of mineral species, but give us no example of the pseudomorphous alteration of serpentine itself. It is, according to Bischof, the very insolubility and unalterability of serpentine which causes it to appear as the final result of the change of so many mineral species. Delesse, moreover, in his carefully prepared table of pseudomorphous minerals, in which he has resumed the results of his own and all preceding observers, does not admit the pseudomorphic replacement of serpentine by calcite, nor indeed by any other species.* If, then,

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* "Annales des Mines," 5, xvi. 317.

such pseudomorphs exist, it appears to be a fact hitherto unobserved, and our authors should at least have given us some evidence of this remarkable case of pseudomorphism by which they seek to support their singular hypothesis.

I hasten to say, however, that I reject with Scheerer, Delesse, and Naumann, a great part of the supposed cases of mineral pseudomorphism, and do not even admit the pseudomorphous origin of serpentine itself, but believe that this, with many other related silicates, has been formed by direct chemical precipitation. This view, which our authors do me the honour to criticise, was set forth by me in 1860 and 1861,* and will be found noticed more in detail in the "Geological Report of Canada, for 1866," p. 229. I have there and elsewhere maintained that "steatite, serpentine, pyroxene, hornblende, and in many cases garnet, epidote, and other silicated minerals, are formed by a crystallization and molecular re-arrangement of silicates, generated by chemical processes in waters at the earth's surface."†

This view, which at once explains the origin of all these bedded rocks, and the fact that their constituent mineral species, like silica and carbonate of lime, replace the perishable matter of organic forms, is designated by Messrs. King and Rowney "as so completely destitute of the characters of a scientific hypothesis as to be wholly unworthy of consideration," and they speak of my attempts to maintain this hypothesis as "a total collapse." How far this statement is from the truth my readers shall judge. My views as to the origin of serpentine and other silicated minerals were set forth by me as above in 1860–1864, before anything was known of the mineralogy of Eozoon, and were forced upon me by my studies of the older crystalline schists of North America. Naumann had already pointed out the necessity of some such hypothesis when he protested against the extravagances of the pseudomorphist school, and maintained that the beds of various silicates found in the crystalline schists are original deposits and not formed by an epigenic process. ("Geognosie" ii., 65. 154, and "Bull. Soc. Geol. de France," 2, xviii., 678.) This conclusion of Naumann's I have attempted to explain and support by numerous facts and observations, which have led me to the hypothesis in question. Gümbel, who accepts Naumann's view, sustains my hypothesis of the origin of these rocks in a most emphatic manner,‡ and Credner in discussing the genesis of the Eozoic rocks, has most ably defended it.§ So much for my theoretical views so contemptuously denounced by Messrs. King and Rowney, which are nevertheless unhesitatingly

* "Amer. Jour. Sci" (2), xxix. 284, xxxii. 286.

† Ibid., xxxvii. 266; xxxviii. 183.

‡ "Proc. Royal Bavarian Acad. for 1866," translated in "Can. Naturalist," iii., 81.

§ "Die Gliederung der Eozoischen Formations gruppe Nord.-Amerikas,—a Thesis defended before the University of Leipzig, March 15, 1869," by Dr. Hermann Credner. Halle, 1869, p. 53.

adopted by the two geologists of the time who have made the most special studies of the rocks in question, Gümbel in Germany, and Credner in North America.

It would be a thankless task to follow Messrs. King and Rowney through their long paper, which abounds in statements as unsound as those I have just exposed, but I cannot conclude without calling attention to one misconception of theirs as to my view of the origin of limestones. They quote Professor Hull's remark to the effect that the researches of the Canadian geologists and others have shown that the oldest known limestones of the world owe their origin to Eozoon, and remark that the existence of great limestone beds in the Eozoic rocks seemed to have influenced Lyell, Ramsay, and others in admitting the received view of Eozoon. Were there no other conceivable source of limestones than Eozoon or similar calcareous skeletons, one might suppose that the presence of such rocks in the Laurentian system could have thus influenced these distinguished geologists, but there are found beneath the Eozoon horizon two great formations of limestone in which this fossil has never been detected. When found, indeed, it owes its conservation in a readily recognizable form to the fact, that it was preserved by the introduction of serpentine at the time of its growth. Above the unbroken Eozoon reefs are limestones made up apparently of the series of Eozoon thus preserved by serpentine, and there is no doubt that this calcareous rhizopod, growing in water where serpentine was not in process of formation, might, and probably did, build up pure limestone beds like those formed in later times from the ruins of corals and crinoids. Nor is there anything inconsistent in this with the assertion which Messrs. King and Rowney quote from me, viz., that the popular notion that *all limestone formations* owe their origin to organic life is based upon a fallacy. The idea that marine organisms originate the carbonate of lime of their skeletons, in a manner somewhat similar to that in which plants generate the organic matter of theirs, appears to be commonly held among certain geologists. It cannot, however, be too often repeated that animals only appropriate the carbonate of lime which is furnished them by chemical reaction. Were there no animals present to make use of it, the carbonate of lime would accumulate in natural waters till these became saturated and would then be deposited in an insoluble form; and although thousands of feet of limestone have been formed from the calcareous skeletons of marine animals, it is not less true that great beds of ancient marble, like many modern travertines and tufas, have been deposited without the intervention of life, and even in waters from which living organisms were probably absent. To illustrate this with the parallel case of silicious deposits, there are great beds made up of silicious shields of diatoms. These during their lifetime extracted from the waters the dissolved silica, which, but for their intervention, might have accumulated till it was at length deposited in the form of schist or of crystalline quartz. In either case the function of the coral, the rhizopod, or the diatom is limited to assi-

milating the carbonate of lime or the silica from its solution, and the organized form thus given to these substances is purely accidental. It is characteristic of our authors, that, rather than admit the limestone beds of the Eozoon rocks to have been formed like beds of coralline limestone, or deposited as chemical precipitates like travertine, they prefer, as they assure us, to regard them as the results of that hitherto unheard-of process, the pseudomorphism of serpentine; as if the deposition of the carbonate of lime in the place of dissolved serpentine were a simpler process than its direct deposition in one or the other of the ways which all the world understands!

MONTREAL, *January* 16, 1871.

XXI.—ON MUSCULAR ANOMALIES IN HUMAN ANATOMY. By ALEXANDER MACALISTER, Professor of Zoology, T. C. D. [Abstract].

[Read January 23, 1871.]

IN this Paper I have recorded all the muscular anomalies which have been seen by me during the past twelve years in the dissecting-room of the Royal College of Surgeons, together with notes of many others which have been communicated to me by several friends and former pupils. These I have tabulated in anatomical order, and I have, as far as I could, given a complete bibliographic record of the subject of abnormal myology; there are thus in the list about two thousand forms of deviation from the average structure in man, over fifteen hundred of which have been noticed by myself. Of these, about a hundred and fifty are novelties, not hitherto described, as far as I am aware. I have not appended to this Paper any generalities, as I have seen no cause to alter any of the opinions which I have before expressed ("Proc." R. I. A., 1867, Dec. 9). Nor have I added any remarks on muscular homologies; for though I have seen reason to depart in some respects from the theory laid down in the paper just quoted, yet I desire that this paper—long enough in itself—should not be encumbered with any theory; and I have therefore carefully confined myself as much as possible to matters of fact. The most interesting question regarding muscular anomalies is that which concerns the relations existing between the departures from average structure in man, and the average or normal arrangements in lower animals; but I have not, except in a few instances, touched upon this, as it would have swelled the paper to inordinate size. Muscles do not seem to vary in lower animals to the extent they do in man, though of course we cannot absolutely know the frequency of such anomalies unless we obtain a record of a much larger number of dissections as data than we have at present. In such animals, however, as I have several

times dissected, to wit, the lion—of which I have carefully dissected four specimens—the dog, rabbit, Macacus nemestrinus (6); M. cynomolgus (3); Cercopitheus sabæus (3); Cebus capucinus (5); Talpa Europæa (4); Ardea comata (3); Diomedea exulans (2); and many other animals, I have found that every second and succeeding dissection of the same species has been precisely identical. Now, there are scarcely two human subjects whose muscular systems in every respect resemble each other, while in the series of each species above named, positively no deviations were met with, though in most cases (all but the dogs and rabbits) both sides were carefully dissected and the muscles weighed; those of one side by the Rev. Professor Haughton, and those of the other by myself. From these data, as well as from the comparison of the records of the dissection by other anatomists of individual species, I think we are warranted in concluding, that there is smaller degree of variation in the muscular system of any well-marked animal form than there is in man.

As to the producing causes of muscular anomalies, we will not be in a position to arrive at any very definite conclusions until we can procure a series of dissections of subjects whose habits of life have been known; for we have reason to believe that they to a large extent are due to variation in habit, and possibly are to a large extent hereditary, as such deformity as the occurrence of six fingers has been proved to be. Sex certainly does seem to influence their development, as stated before; and from the different degrees of frequency of certain anomalies, catalogued by Professor Wenzel Gruber, of St. Petersburg, Professor John Wood, of King's College, London, and myself in Dublin (where the largest number of subjects dissected are mainly of Celtic origin), it would seem that there was a difference in the relative frequency of certain varieties in Celtic, Saxon, and Sclavonic races. I have not met with any record of an extensive series of dissections of negroes or of other races, but it is probable that in these there would be found similar varieties of development, which might admit of tabulation as race characters. When the plan introduced by the Rev. Dr. Haughton, of weighing the muscles becomes adopted generally in such dissections, we may look for the recognition of such characters.

The number of subjects which have come under my observation since I began to tabulate muscular anomalies has been nearly nine hundred: of these I have superintended the dissection and examined the abnormalities of fully six hundred and ninety, and I have had the anomalies in the others pointed out to me by those who superintended their dissections. I have especially to thank Dr. Kelly, Demonstrator of Anatomy, Carmichael Medical School; Dr. Ward, Demonstrator in the Medical School of the Catholic University; Dr. Bookey, of Steevens' Hospital; Dr. Walter Smith, of the University Medical School; and Drs. Hewitt and Stoker, of the Royal College of Surgeons, for showing me numerous rare forms of abnormality.

XXII.—ADDENDUM TO PAPER ON EOZOON. By J. W. DAWSON, LL. D., F. R. S., Principal of the M'Gill College, Montreal.

[Read April 10, 1871.]

IN pursuing the researches referred to in the Paper read before the Academy, February 13th, 1878,* two points have occurred which are, in my opinion, so instructive that I desire to add a short notice of them.

The first relates to a limestone, probably of Upper Silurian age, collected by Mr. Robb, of the Geological Survey, and kindly placed in my hands by Mr. Selwyn. The locality is Pole-hill, New Brunswick. This limestone is composed almost wholly of organic fragments, cemented by crystalline carbonate of lime, and traversed by slender veins of the same mineral. Among the fragments may be recognised under the microscope portions of Trilobites, and of brachiopod and gasteropod shells, and numerous joints and plates of Crinoids. The latter are remarkable for the manner in which their reticulated structure, which is precisely similar to that of modern Crinoids, has been injected with a siliceous. substance, which is seen distinctly in slices, and still more plainly in decalcified specimens. This filling is precisely similar in appearance to the serpentine filling the canals of Eozoon, the only apparent difference being that in the forms of the cells and tubes of the Crinoids, as compared with those of the Laurentian fossil, the same silicious substance also occupies the cavities of some of the small shells, and occurs in mere amorphous pieces, apparently filling interstices. From its mode of occurrence, I have not the slightest doubt that it occupied the cavities of the crinoidal fragments while still recent, and before they had been cemented together by the calcareous paste. This siliceous filling is therefore similar, on the one hand, to that effected by the ancient serpentine of the Laurentian, and on the other to that which results from the deposition of modern glauconite. The analysis of Dr. Hunt, which I give below, fully confirms these analogies.

I may add that I have examined under the microscope portions of the substance prepared by Dr. Hunt for analysis, and find it to retain its form, showing that it is the actual filling of the cavities. I have also examined the small amount of insoluble silica remaining after his treatment with acid and alkaline solvents, and find it to consist of angular and rounded grains of quartzose sand.

The following are Dr. Hunt's notes:—

"The fossiliferous limestone from Pole-hill, New Brunswick, probably of Upper Silurian age, is light gray and coarsely granular. When treated with dilute hydrochloric acid, it leaves a residue of 5·9 per cent., and the solution gives 1·8 per cent. of alumina and oxide of iron,

* "Proceedings R. I. A.," New Series, vol. i., p. 117.

and magnesia equal to 1·35 of carbonate—the remainder being carbonate of lime. The insoluble matter separated by dilute acid, after washing by decantation from a small amount of fine flocculent matter, consists, apart from an admixture of quartz grains, entirely of casts and moulded forms of a peculiar silicate, which Dr. Dawson has observed in decalcified specimens filling the pores of crinoidal stems, and which, when separated by an acid, resembles closely under the microscope the coralloidal forms of arragonite known as *flos ferri*, the surfaces being somewhat rugose and glistening with crystalline faces. This silicate is sub-translucent and of a pale green colour, but immediately becomes of a light reddish brown when heated to redness in the air, and gives off water when heated in a tube, without, however, changing its form. It is partially decomposed by strong hydrochloric acid, yielding a considerable amount of protosalt of iron. Strong hot sulphuric acid readily and completely decomposes it, showing it to be a silicate of alumina and ferrous oxide, with some magnesia and alkalies, but with no trace of lime. The separated silica, which remains after the action of the acid, is readily dissolved by a dilute solution of soda, leaving behind nothing but angular and partially rounded grains of sand, chiefly of colourless vitreous quartz. An analysis effected in the way just described on 1·187 grammes gave the following results, which give, by calculation, the centesimal composition of the mineral:—

Silica, ...	·3290	38·93	= 20·77	oxygen.
Alumina, . . .	·2440	28·88	= 13·46	„
Protoxyd of iron, .	·1593	18·86		
Magnesia, . . .	·0360	4·25		
Potash, ...	·0140	1·69	= 6·29	„
Soda, ...	·0042	·48		
Water, ...	·0584	6·91	= 6·14	„
Insoluble, quartz .	·3420	. .	. .	
	1·1869	100·00		

"A previous analysis of a portion of the mixture by fusion with carbonate of soda gave, by calculation, 18·80 p. c. of protoxide of iron, and amounts of alumina and combined silica closely agreeing with those just given.

"The oxygen ratios, as above calculated, are nearly as 3 : 2 : 1 : 1. This mineral approaches in composition to the jollyte of Von Kobell, from which it differs in containing a portion of alkalies, and only one half as much water. In these respects it agrees nearly with the silicate found by Robert Hoffman, at Raspenau, in Bohemia, where it occurs in thin layers alternating with picrosmine, and surrounding masses of Eozoon in the Laurentian limestones of that region;* the Eozoon itself being there injected with a hydrous silicate which may be described as intermediate between glauconite and chlorite in composition. The

* "Jour. für Prakt. Chemie," Bd. 106 (Erster Jahrgang, 1869), p. 356.

mineral first mentioned is compared by Hoffman to fahlunite, to which jollyte is also related in physical characters as well as in composition. Under the names of fahlunite, gigantolite, pinite, &c., are included a great class of hydrous silicates which, from their imperfectly crystalline condition, have generally been regarded, like serpentine, as results of the alteration of other silicates. It is, however, difficult to admit that the silicate found in the condition described by Hoffman, and still more the present mineral, which injects the pores of palaeozoic Crinoids, can be any other than an original deposition, allied in the mode of its formation to the serpentine, pyroxene, and other minerals which have injected the Laurentian Eozoon, and the serpentine and glauconite, which in a similar manner fill tertiary and recent shells."

The second point to which I would refer, is the alleged occurrence of the structures of Eozoon in connexion with crystals of spinel, from Amity, New York. I have examined the specimens of this mineral and its matrix, within my reach, with the following results:— A specimen from that locality in the collection of M'Gill College, and another in that of Dr. Hunt from that vicinity, contain in spots, remains of casts of canals similar to those of *Eozoon Canadense* apparently belonging to fragments of this fossil. From the general structure and aspect of these specimens, however, I infer that they are portions of a bedded rock and not a veinstone. In fact, they closely resemble specimens in the collection of the Geological Survey, from Newborough, Ont., which have been described by Dr. Hunt; in which large grains and imperfect crystals of chondrodite, sometimes one-fourth of an inch in diameter, "mark the planes of stratification in a bedded limestone." Both chondrodite and spinel are by him stated to occur in the bedded crystalline limestones of the Laurentian, as well as in the calcareous veinstones (Report Geol. Canada, 1866, pp. 206 and 213). It is worthy of remark that there are numerous other specimens in the collection of Dr. Hunt from Amity and the adjacent region, which are clearly calcareous veinstones, often containing chondrodite, spinel, pyroxene, &c., which exhibit no trace of Eozoon. Gümbel also, in his extensive examination of crystalline limestones in 1865, could detect no Eozoon in the coarsely crystalline carbonate of lime with chondrodite, from Amity; and, I think, it will be found that carbonate of lime holding Eozoon, associated with chondrodite and spinel, either formed part of a bedded rock, or possibly, in some cases, may have been derived from a fragment of such rock enclosed in a veinstone.

XXIII.—On the Geological Age and Microscopic Structure of the Serpentine Marble or Ophite of Skye.* By Professors W. King, Sc.D., and T. H. Rowney, Ph. D. (With plate xiv., Science).

[Read 14th January, 1871.]

FIRST PART.

While on a tour in the months of June and July of the past year, one of us visited a portion of the Western Highlands and the adjacent islands of Scotland, when the opportunity was embraced of making an examination of the Kilbride district of Strath, in Skye. Although the geology of the part examined has been to a considerable extent described by Dr. Macculloch† and Mr. Archibald Geikie‡—by the latter especially—several questions have of late years arisen that render the present paper not altogether unnecessary.

The district referred to, which is situated on the east side of Lough Slappin, between Torrin on the north, and Glen Suishnish on the south, consists of rocks belonging to the two great classes.§

The principal igneous rock appears like a protruded mass, which, on the shore, is about half a mile in width; while inland, and stretching eastward for a few miles, it constitutes the rather elevated ridge, called Beinn-an-Dubhaich. Both on its north side, at the promontory near Torrin, and on its south side near Camus Smalaig, the igneous mass is flanked by saccharoid calcitic marble in rudely stratified beds, which dip away from it at a high angle. These are overlaid by a succession of normal sedimentary deposits, with, as the distance increases, a gradual decreasing inclination.

The igneous rock, usually considered a syenite, is somewhat variable in mineral composition; but in general it is crystalline throughout, and composed essentially of felspar (of two kinds—a pale flesh-coloured orthoclase, and apparently a white albite) and quartz, in about equal proportions, with a comparatively small amount of amphibole (hornblende). The rock, on account of the small proportion of the last mineral, cannot be considered a typical syenite. We quite agree, however, with Geikie, in "ranking it among the granites."

The marble is white, more or less crystalline—sometimes compact and waxy; and containing here and there grains, strings, nests, layers, and irregular lumps, of serpentine, and other mineral silicates, that give it the character of ophite. Some of the additional substances

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* A paper by the authors was read at the Liverpool meeting of the British Association, entitled, "On some points in the Geology of Strath, in Skye." A considerable portion of it is included in the first part of the present memoir, while the subject of the second part is differently treated to what it was in the Liverpool paper; and several new points are added.

† "The Western Highlands of Scotland," vol. i., pp. 262–419.

‡ "Quarterly Journal of the Geological Society," vol. xiv., pp. 1—36, 1857.

§ See Section in Plate xiv., fig. 1.

are of a doubtful nature, appearing more or less like amorphous amphibolic matter, or imperfectly developed serpentine. Calcareous layers, faintly crystalline, and containing flattened pieces of a dark green serpentine-like substance, are present in some parts of the marble.

Want of time prevented any observations being made with the object of determining the relation between the afore-mentioned siliceous minerals and the "augitic greenstone" of the dykes that cut through the marble.* Serpentine, according to the highest authorities, is considered to be in *all cases* a pseudomorph. Such we assume to be the case with the "green streaks" of this mineral, "which," according to Geikie, "mottle the marble where it is intersected by trap dykes;" and hence they may be pseudomorphic after the "augitic greenstone."

The junction between the syenite and the marble is not ill-defined; but no veins were observed carrying the one into the other. The contact surfaces are rugged, with irregular projections and hollows.

The beds adjacent to the marble are calcareous, have a blue greyish colour, and contain numerous white irregularly-shaped siliceous concretion-like bodies; which, as suggested by Macculloch and Geikie, may possibly be fossil remains that have lost all traces of organic structure through semi-metamorphism.

Next follows a considerable thickness of hard limestones: some blackish-grey, with thin irregular laminæ of sandy argillaceous matter; others of a lighter colour, largely composed of minute siliceous particles, apparently sand. Some of the beds contain numerous minute spheroidal bodies, which, when sections are examined with an ordinary magnifier, show nothing more than the appearances peculiar to oolitic grains. At first sight the more spherical forms might be taken for fossil Orbulinas; but, as they completely fail in showing any shell-structures, their foraminiferal nature is rendered doubtful. There are also numerous small pieces with the characteristic cleavage of calcite; many of which appear to be of crystalline origin; but some, we have no doubt, are fragments of Encrinites. Possibly it was in some of the limestones under consideration that Mr. Geikie found "what appeared to be fragments of a Pentacrinite." Be this as it may, true fossils do occur in the whole series; since we have detected with a common lens shells of Foraminifera in abundance. We have also observed a few cylindrical bodies, longitudinally fluted, and somewhat thicker than a pin: examined with a higher power, transverse sections of the latter show them to possess internally a radial structure; the ribs corresponding to the radii; which is suggestive of their being the remains of minute echinidial spines. There are likewise present numerous fragments of very small bivalve and univalve shells. In the same series of beds was also found the complete rim of a concave calice of

* Geikie, "Quarterly Journal of the Geological Society," vol. xiv., p. 19.

a turbinoid coral, nearly an inch and a quarter in diameter. The plates were numerous, but they were only seen to pass from the rim to about half way to the centre of the calice, possibly owing to its being deeply concave. Unfortunately, in trying to detach the specimen, which was slightly in relief, it broke into fragments. To all appearances it belonged to a large species of *Montlivaltia*: the circularity and large size of the calice are against its being an isolated corallite of *Isastræa Murchisoni*; a species forming a reef in the Lias at Lussay, on the opposite coast of the island.

The succeeding rocks, limestones of a dark colour, and of a less crystalline character than those last described, are highly fossiliferous; some being formed entirely of fragments of shells, amongst which were found portions of a small ammonite, and detached valves of a shell resembling *Avicula decussata.*

Shales and other limestones follow; and these are distinguished by an immense number of *Gryphæa obliquata*, and other Liassic fossils.

All the foregoing stratified rocks gradually fall from a nearly vertical position, which obtains at the junction of the marble with the syenite at Camus Smalaig, to about 20 degrees—apparently the angle of the highest gryphæa beds near Suishnish Glen. In no part of the section, which does not exceed a mile in extent, was any certain case of stratial disruption or unconformability observed.

Reverting to the marble, both Macculloch and Geikie express themselves in favor of its being a metamorphic rock of Liassic age, the contiguous syenite having been the metamorphosing agent. Some, it would seem, are indisposed to accept this conclusion. "With all due deference to the authority of that eminent geologist, Mr. Geikie," Dr. Hunt avers he "cannot help suggesting that a re-examination of the district of Strath would show that the highly metamorphosed crystalline limestones, holding serpentine, and associated with syenitic rocks, belong to an older system (probably Laurentian), and are thus distinct from the nearly horizontal fossiliferous limestones near by, which are locally altered by intrusive rocks."* Unfortunately for this suggestion, all the evidences are against it. And it so happens that the fossiliferous limestones referred to, which have an inclination of about 20 degrees, regularly graduate in angle, and to some extent in structure, into the "highly inclined metamorphosed crystalline limestones;" while the short space between the marble, and the beds nearest to it yielding the fragments of ammonite, &c., shows no want of conformability. And what is further confirmatory of the conclusion, objected to by Dr. Hunt, is the repetition of a similar stratigraphy on the other or Torrin side of the syenite. The difference between the angle of the crystalline marble and that of the highest of the fossiliferous limestones, has evidently been caused by the latter being at the greatest distance from the syenite: the limestone would not, as a consequence, be so much tilted as the marble.

* "Silliman's American Journal," March, 1870, p. 186.

Thus, weighing all the facts and considerations that have been adduced, we are compelled to reject the view to which Dr. Sterry Hunt is inclined, and to accept the one long ago advocated by Macculloch and Geikie.* The two following conclusions are the legitimate expressions of the old view.

1st. That the ophite of Skye is an altered rock of the Liassic period.

2nd. That igneous action, developing a granitic rock, and producing decided metamorphism in an adjacent deposit, has operated at a later geological period in Skye than in any other part of the British Islands.

Geologists, it is true, are already acquainted with a comparatively modern granitic formation in Arran and Devonshire; but the evidences bearing on these cases go no furthur than to show that the former is post-Carboniferous, and that the latter is probably pre-Triassic. Now, however, a rock of the same class may be pointed out that can only be considered to have been developed during some post-Liassic period.

SECOND PART.

The serpentine appears to be rare at Camus Smalaig; and it is not common at Torrin. But near the Manse at Kilbride, about half a mile inland, serpentinous marble seems to be rather abundant; as blocks of true ophite are common in the old walls about the place. The serpentine generally occurs in thin anastomosing parallel layers, averaging an eighth of an inch in thickness, alternating with plates of corresponding thickness composed of calcite. Both are often sharply and complexly crumpled; and in many cases they are seen concentrically curling round concretion-like nuclei of compact serpentine, or other mineral silicates, in which, the calcareous plates disappearing, the siliceous layers lose their individuality.

In its laminated portions, the Skye marble remarkably resembles the celebrated "eozoonal" ophite of Canada—more so in this respect than the corresponding rock, common in Connemara. Figure 2, pl. XIV. (Science), represents a portion of a large block, in which the laminæ, singularly curved, are well displayed. As in other cases that are known to us, the concentric arrangement of the laminæ around nuclei is more suggestive of a superinduced than a depositional origin.

It will be recollected by those who have made themselves acquainted with the discussion, so rife of late years, respecting the so-called "*Eozoon Canadense*," that, in our memoirs on the subject, we have described and figured certain microscopic structures observed in a small piece of Skye ophite, evidently from the Kilbride district, which was

* M. Geikie, in a memoir published subsequently to the one we have already referred to, observes that "some parts of the metamorphic limestone of Strath may possibly be Silurian" ("Quart. Jour. Geol. Soc.," vol. xvii., p. 200); but we take this observation to apply to a calcareous rock, which occurs near Heast on Loch Eishort.

presented to us by Professor Harkness.* We showed these structures to be unmistakably "eozoonal." It consequently gave us much pleasure in finding that our Strath specimens afford additional evidences supporting the view we have taken in the discussion.

In the Skye ophite the mineral silicates consist of sub-translucent pale green or yellowish serpentine, which is also opaque and whitish where it is granular or flocculent,—a white granulo-crystalline mineral occasionally displaying cleavage, which we refer to malacolite,—and a greenish black one somewhat resembling amphibole, and similar to the last in texture; while the mineral carbonates which enclose the latter, forming, as it were, their matrix, occur as calcite and dolomite. Cases are common in which the serpentine appears to melt insensibly into the malacolite, and the malacolite into the amphibole-like species. Similar differences of mineral composition and arrangement characterize the Laurentian "eozoonal" marble of Canada.

Sir William Logan has represented a laminated specimen, from the Calumet, in which the mineral silicate consists of "white pyroxene"† or malacolite. In this respect it is identical with the Skye specimen represented in fig. 3, pl. XIV.

Principal Dawson has represented another specimen from Burgess, with "dark green loganite" and dolomite in alternating layers.‡ The Skye specimen, shown in fig. 4, pl. XIV., we strongly suspect is the same; as its greenish-black mineral appears to be identical with, or closely related to, loganite; a variety which Dana considers to be a pseudomorph after amphibole;§ while its mineral carbonate appears to be dolomite.

The finest specimens of the two last varieties were procured from near Torrin; where the serpentine, which occurs as strings and indefinite aggregations, is not abundant.

The layers of mineral silicates in the Canadian ophite, also the grains when separated and irregularly arranged, are considered to be *casts* of the "chambers" of "Eozoon;" and the interlaminated or interstitial calcite is taken for its "skeleton." In these two features, the presumed organism comes well out in the Skye ophite; as it also does in its remaining features—the "nummuline layer" and "canal system."

Professor Harkness's specimen shows the grains of serpentine in many cases invested with aciculi, closely agreeing in their parallelism and cylindrical form with those of the "nummuline layer" in its typical state, as characterizing the Canadian rock. With the exception of a few rather obscure traces, here and there, we have not yet detected any good examples of this feature in our recently acquired

* "Quart. Journ. Geol. Soc.," vol. xxii., p. 204; "Proc. Roy. Irish Acad.," vol. x., pl. XLIV., fig. 10.

† "Geology of Canada," 1863, p. 49, figs. 3 and 4.

‡ "Quarterly Journal of the Geological Society," vol. xxi., pl. VII., fig. 1.

§ "System of Mineralogy," 5th ed., pp. 221, 242, 496.

specimens: its absence, however, is readily explained by the fact that the grains of serpentine on their surfaces are for the most part flocculent—a condition which experience teaches us is incompatible with the co-existence of a fibrous coat. Fig. 5, pl. XIV., represents an example of it, in addition to the larger and more varied one given in our last memoir.

As regards the structures presumed to have formed the "canal system," we find our Skye specimens containing finer and more numerous examples than we were led to expect, judging from the inferiority of those that occurred to us in the pre-cited specimen:* still we have failed in detecting any so remarkable as some we have seen in the Canadian ophite. As in the latter rock, many consist of serpentine, and others of malacolite: both kinds are irregularly rounded and excavated; and, besides being simply rod-like, they are often remarkably subdivided or branching. The serpentinous examples (fig. 6, pl. XIV.) are usually of a dull-white colour, and somewhat nodulose; while those in malacolite (fig. 7, pl. XIV.) have often crystalline planes, a vitreous lustre, and a beaded appearance. In the specimens laminated with the amphibole-like mineral, the dolomite intercalations are crowded with miniature examples of typical forms.

Having elsewhere entered considerably into detail in disproof of the view advocated by others as to the origin of the different "eozoonal" features, we have no intention of taking up the matter in the present Paper, except so far as it bears on certain pseudomorphic phenomena; a subject, which, with few exceptions, has been singularly neglected by geologists of this country. The evidences we have adduced, as observed in various ophites and other crystalline rocks, all combine to prove—that the "chamber casts" and "canal system" have resulted from structural and chemical changes, inherent in and peculiar to the mineral silicates composing them—that this is also the case with the "nummuline layer," which we have shown originated from chrysotile, a fibrous variety of serpentine—and that the substance (calcite, or dolomite) of the "skeleton" has replaced one or other of the mineral silicates, consequent on the partial or complete removal of the latter by the above changes. The same conclusions are forced on us by an examination of the Skye specimens.

As the malacolite exhibits most instructively the origin of three of the foregoing features,† we propose in the next place to give a brief account of our observations in connexion with this point. Being granulo-crystalline, the present mineral often exhibits itself as grains—usually elongated spheroids—with planes, edges, and angles. Generally, however, these parts are rounded off, and the resulting surfaces display precisely the appearance of having been produced by some dissolving agent. These peculiarities characterize the grains, whether they occur singly, or in laminar aggregations ("chamber casts"); or at-

* "Quarterly Journal Geological Society," vol. xxii., p. 204.

† The "nummuline layer" seems to be restricted to serpentine.

tached to one another under the extremely varied and dissimilar forms constituting the "canal system." Even the most branching of the latter show by their occasional angularities, excavated and rounded surfaces, and beaded character, that they are entirely made up of crystalline grains—skeletons of larger groups—reduced and fashioned into their present remarkable shapes by the wasting action of a solvent. Moreover, isolated grains occur with a thin white crust enclosing their translucent substance: others are seen with a portion of their substance removed, but the crust remaining and intact; while close by are hollow spheroidal cases identical with the crusts. These facts, which are, of course, best revealed by decalcifying the specimens,* prove beyond doubt that the vacancies in the grains were occupied by calcite.

Clearly the grains at one time were altogether composed of malacolite; and it is equally clear that the calcite now occupying the vacancies has replaced the malacolite. The substitution of a siliceous mineral by a calcareous one is seen in all its stages; and it is as self-evident a case of pseudomorphism as any that have been recorded. The spheroidal grains of malacolite, with their external crust preserved, and enclosing an interior of calcite, are precisely analogous to the "crystals of garnet from Tvedestrand, which are wholly calcite within, there being but a thin crust of garnet."†

Again, the crust itself exhibits most obviously the final stage of its waste. Unmistakable portions are seen fixed in the undissolved part of the calcareous intercalations; and when a number of such, belonging to different grains, are attached to one another, they give rise to irregularly undulating leaf-like expansions, some of which strikingly resemble the "curiously curved" configurations detected by Dr. Gümbel in a Bavarian ophite, and considered by him to represent the "canal system" of his so-called "*Eozoon Bavaricum.*"‡ These examples are demonstratively fragments of branching varieties of the "canal system;" and they must be accepted as completely confirming our view of the origin of this feature. Ocasionally, crusts may be seen entirely riddled, and approximately simulating in this respect the perforated shell-case of a globular polycystine.§

Now, considering that the grains of malacolite show themselves in every stage of decretion, it clearly follows that in numerous instances they have disappeared altogether; and it is equally to be inferred that the interstitial calcite, or dolomite—even that forming the layers—has replaced a corresponding amount of malacolite. In both cases the change may have been effected by the rock having been permeated by heated water holding a carbonate in solution.

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* By this process the calcite of the grains is removed, as well as that forming the adjacent calcareous layers and interstices.

† "Dana's Syst. Mineralogy," 5 ed., p. 272.

‡ "Canadian Naturalist," vol. iii., plate I., fig. 7.

§ Skeletons of apparently the grains of the amphibole-like mineral also occasionally occur as thin porous or rudely reticulated fragments.

These inferences open out a wide field of speculation in pseudomorphic geology: and it becomes a legitimate question—whether the Skye ophite may not have been, previous to its present condition, altogether a different rock, essentially composed of calcareo-magnesian silicates, which became calcitic, or dolomitic by the elimination of its silica, and the replacement of this substance by carbonic acid.*

But whatever view may be taken respecting the mineralogical characters of the rock under consideration, in its pre-ophitic condition, we entertain no doubts as to our having fully and clearly established the truth of the two following conclusions:—

1st. That all the microscopic forms characteristic of the Laurentian ophite of Canada are more or less paralleled by those occurring in the Liassic ophite of Skye.

2nd. That the microscopic forms in the Skye ophite are the result of structural and chemical changes, to which its essential siliceous minerals are characteristically liable.

A few words more. It cannot be too strongly enforced that malacolite, loganite, and serpentine, belong to one and the same class of mineral silicates, having a close pseudomorphic relation; and that they consequently represent a series of chemical changes; also, that dolomite and calcite, which are similarly related to each other, occur as pseudomorphs after mineral silicates. Crystals of garnet, labradorite, orthoclase, albite, &c., are well known to occur changed into a carbonate (calcite, &c.).†

DESCRIPTION OF FIGURES IN PLATE XIV. (SCIENCE.)

Fig. 1.—Coast section, about one mile in length, on the east side of Loch Slappin, Isle of Skye.

Fig. 2.—Layers of serpentine, &c. ("chamber casts" of "*Eozoon Canadense*"), with calcitic spaces ("intermediate skeleton") between them, curling round siliceous nuclei: natural size, as seen in a large block of ophite, from near the Manse, Kilbride, in Skye.

Fig. 3.—Layers of malacolite or white pyroxene, separated by calcitic layers: natural size, from a weathered specimen of ophite, near Torrin, Skye.

Fig. 4.—Layers of a dark-green mineral (? loganite), separated by dolomitic layers: natural size, from weathered ophite, near Torrin, Skye.

Fig. 5.—Cylindrical parallel aciculi ("nummuline layer") on the sectional edge of a piece of serpentine: highly magnified. In ophite, from Strath, Skye.

Fig. 6.—Simple and branching configurations ("canal system") composed of serpentine, and imbedded in calcitic layers ("intermediate skeleton") of ophite, from Strath, Skye. Highly magnified.

Fig 7.—Configurations composed of malacolite, and imbedded in calcitic layers of ophite, from Strath, Skye. Highly magnified.

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* In some varieties of the amphibole group, the basic constituents solely consist of lime and magnesia. Malacolite, according to Dana, is composed of—Sil., 55·7; lime, 25·8; mag., 18·5; and tremolite is formed of the same salts, but inversely proportioned.

† See "Dana," pp. 272, 344, 361, 678.

XXIV.—On the Mineral Origin of the so-called "Eozoon Canadense." By Professors William King, Sc. D., and Thomas H. Rowney, Ph. D.

[Read April 10, 1871.]

The only replies that have appeared to our former Paper* on "Eozoon" are by Drs. J. W. Dawson and T. Sterry Hunt.† As one confines himself to "the discussion of the zoological aspects of the question," and the other to certain of its chemical and mineralogical relations, we shall consider their Papers separately. To begin with the first. We intend to review Dr. Dawson's paragraphs *seriatim;* of course omitting to notice any remarks that contain nothing of importance.

1st. Fully believing that Dr. Dawson can employ his time *more usefully* on other subjects than that of "Eozoon," we are quite willing to his renouncing the "controversy" altogether. For our part, feeling convinced that we have irrefragably established the purely mineral origin of "Eozoon Canadense," and considering the way in which the organic theory is maintained, we are quite as "reluctant" as Dr. Dawson appears to be in prolonging the discussion. It is only "in the interest of truth" that we commenced it, or keep it open.

2nd. Dr. Dawson maintains the organic origin of certain structures; and has a perfect right to represent them as such. On the other hand, we, contending for their purely mineral origin, claim an equal right to describe them according to our view.

3rd. The statement respecting the Tudor specimen will be noticed under the 6th paragraph.

4th. We totally repudiate the charge of having shown any "anxiety" to "ignore the specimens of 'Eozoon' preserved under different mineral conditions." We have *fully* discussed such specimens as far as the evidences enabled us, which may be considered to argue the contrary.

5th. We have certainly admitted our "inability to explain satisfactorily the alternating layers of carbonate of lime and other minerals" in "Eozoon:" but how this is "fatal" to our "case" surpasses our comprehension; as we have pointed out analogous examples which occur under circumstances proving that the alternation can only be a mineral arrangement.‡ The analogies we have adduced, Dr. Dawson may say "are clearly not parallel;" but he has failed to make his statement clear to others. As we have no faith in the success of any "attempt" to explain the "connecting plates and columns" on any "*concretionary* hypothesis," clearly we are under no necessity to do

* "Proceedings of the Royal Irish Academy," vol. x., pp. 506-551.

† *Ib.*, New Series, vol. i., Part 2.

‡ "Quarterly Journal Geol. Soc.," vol. xxii., p. 210; "Proceedings Royal Irish Academy," vol. x., p. 532.

so. Dr. Dawson, who is evidently unacquainted with our "singular theory of pseudomorphism," would have been correct had he qualified it as *decretionary*.

6th. No grounds, as far as we can recollect, have been stated by us for our "appearing to admit that if specimens occur wholly composed of carbonate of lime," the "theory" we have proposed "will fall to the ground:" on the contrary, as stated, we see no reason why specimens of the kind should not be found.* It might rather be assumed, from the way Dr. Dawson announced the discovery of an example of "Eozoon preserved simply in carbonate of lime"—of its being "a conclusive answer to our objections"—that he felt *his* theory required the occurrence of such specimens. As regards the Tudor specimen, it will be recollected that, after minutely discussing Dr. Dawson's description of it, we could come to no other conclusion (for which our *reasons were given*) than that "it is nothing more than the result of infiltration of carbonate of lime, which has penetrated into a parting between two layers of the laminated arenaceous calcareous rock containing it."† We may be wrong in taking this particular view: at any rate it implies, what we fully believe, that the specimen is of mere mineral origin. Now, Dr. Dawson was in a position to show the unsoundness of our reasons, or to refute our conclusions, if either were incorrect, by bringing forward further arguments or evidences belonging to the specimen; but instead of anything of the kind having been done, we are simply met by the assertion that "since the account of that specimen was published, additional fragments have been collected, the chambers of which are filled with a dark coloured limestone." A similar statement, it will be recollected, was made respecting what were called "chambers" in the original specimen; but which, from any evidence that appeared to the contrary, are no more "chambers" than the meshes between anastomosing strings of calcite. The simple fact of the specimen consisting of a thin expansion, scarcely *two lines in thickness*, of sparsely anastomosing string-like ribs, occupying a space of *six inches and a half by four inches*, and "lying flat on the plane of stratification," is quite sufficient to prove that it is neither a detached section of (as assumed), nor anything else related to, "Eozoon." Our points of objection to all the alleged cases of a calcareous "in-filling," and our complaints respecting the "very meagre and unsatisfactory accounts" hitherto published of them, ought to have induced Dr. Dawson to have given a detailed description, with illustrations if needed, of the "additional fragments." Had the Tudor specimen and the Madoc obscurities been so ecstatically flourished by us, as conclusively disproving the organic origin of "Eozoon" we would have evoked nothing less than universal derision. It must not be overlooked that such cases *must now* be properly examined from a mineralogical

* "Proceedings of the Royal Irish Academy," vol. x., pp. 532, 548.
† "Proceedings of the Royal Irish Academy," vol. x., pp. 511, 512.

point of view before their organic origin can be admitted. . . . . The post-Laurentian age of the Tudor limestones now appears to be established. Mr. H. G. Vennor, to whom is due this credit, is disposed to correlate them with the Potsdam group—the probable equivalent of the Cambrian Lingula flags; and Dr. S. Hunt, who seems to agree with him, has ventured to include them in his "Terranovan Series."* Dr. Dawson states that they are not more metamorphosed than many of those which retain fossils in the Silurian system.† Now, Potsdam or "primordial" fossils are *abundant* in some of the rocks in Newfoundland and New Brunswick, with which the Tudor limestones have been correlated: hence, if the "creature of the dawn" lived in the Terranovan age, surely we have a right to expect the Tudor limestones—so highly promising in organic remains as they now appear to be from Dr. Dawson's statement (also other Terranovan deposits that are fossiliferous)—to afford indisputable evidences of its existence, instead of the mere "fragments" and other extremely doubtful examples they have hitherto yielded. . . . There is one point not to be lost sight of in connexion with the last specimens. Their presumed organic nature would never have been determined except by comparing them with the *perfect* specimens of "Eozoon" that occur in the "*highly crystalline*" (Dawson) rocks of the Laurentian system! Is not this circumstance the very reverse of what a palæontologist, conversant with mineralogy, can accept before he allows himself to embrace the various mysteries that make up the eozoonal belief?

7th. We objected to Dr. Dawson assuming the laminated arrangement to be typical, when, from the description of "Eozoon," as given by different writers, and from our own observations, it appeared to be exceptional. Besides, we have nowhere "reasoned from fragments confusedly intermixed," but from examples of "unbroken" acervuline arrangement; which, understanding it to be the general one, we must still consider to be typical. The *Tetradium* illustration is entirely inappropriate.

8th. We are not aware of having stated anything implying the opening sentence of this paragraph. The "chamber casts" usually consist of serpentine—occasionally of malacolite, and loganite; and it ought to be known to Dr. Dawson that these minerals have no relation, as we have already pointed out, to the ordinary in-filling substance forming the casts of recent and fossil foraminifers:‡ nor do they occur in fossils, except, perhaps, in such as are metamorphosed. Our experience of calcareous organisms found in limestone is, that "*weathering*" *developes them;* the cause of which is due to their being usually in a different molecular condition—crystalline, or semi-crystalline—to that of the rock containing them. "The fragmental specimens from Madoc," stated to be "actually wholly calcareous," also

* "American Journal of Science," July, 1870, pp. 511, 512.

† *Nature*, No. 67, p. 287.

‡ "Proceedings of the Royal Irish Academy," vol. x., p. 540, also, see Postscript.

others of the kind, have already been disposed of,* and ought not to have been *again* introduced, unless supported by fresh and *reliable* evidences.

9th. We have always admitted that the "true cell-wall presents minute cylindrical processes traversing carbonate of lime, and usually nearly parallel to each other,"—even *before* Dr. Dawson had published any description of them:† and we have throughout persistently used the term "*aciculi*" for the "casts of the tubuli;" by which we wished them to be understood as having a "cylindrical" form.‡ What is there to justify Dr. Dawson in again repeating that we "confound the nummuline layer with fibrous and acicular crystals?"§ No doubt Dr. Dawson has "very often shown to microscopists and geologists the cell-wall with veins of chrysotile, and coating of acicular crystals occurring in Eozoonal limestone; and that they have never failed at once to observe the difference;" but it may be allowed us to add that we could show them the originals of the cases figured in our papers, representing intermediate examples graduating the "cell-wall," in its "true" condition, into chrysotile; also, the latter passing into structureless serpentine.‖ . . . It would now appear that Dr. Dawson will not admit many of the modifications described by Dr. Carpenter to represent the "cell-wall" in its various conditions of formation; but rather its accidental or mineral alterations. In such cases as the one represented in the *Intellectual Observer*, vol. vii., uncoloured plate, fig. 2, the "casts of the tubuli" are "glued together by concretions of mineral matter." This is one way of getting out of the difficulty; but it is an escape from Scylla to be wrecked in Charybdis. Dr. Dawson has now no other alternative but to account for the disappearance of the calcareous portion of the "cell-wall" to enable the casts of the tubuli to become "glued together" by what *is siliceous* "mineral matter;" and this involves our "singular theory of pseudomorphism"! . . . In our last paper, we accepted Dr. Dawson's first description of the "true cell-wall," as consisting of "slender undulating rounded threads of serpentine penetrating a matrix of carbonate of lime:" and we are now quite ready to accept his latest and additional statement—that it presents the serpentinous threads "often slightly bulbose at their extremity;" as we perceive something similar in the cylindrical threads of serpentine that line the walls in a true fissure.¶ . . . It is our theory,

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* "Proceedings of the Royal Irish Academy," vol. x., pp. 522, 523.

† Dr. Dawson has not, up to the present time, even given a representation of the "true cell wall." Indeed, this part has not yet been represented in any definite manner to illustrate its presumed typical characters, except by ourselves!

‡ "Quarterly Journal Geol. Soc.," vol. xxii., p. 194.

§ It must not be understood that we consider the aciculi to be in all cases "cylindrical;" because, having originated, as we believe, from prismatic fibres in the form of chrysotile, it is quite probable that they do not always lose their angularities.

‖ "Quarterly Journal Geol. Soc.," vol. xx., pl. xiv., figs. 1, 2, p. 92; "Proc. Royal Irish Academy," vol. x., pl. xli., fig. 1, 2, pp. 515, 516.

¶ "Quarterly Journal Geol. Society," vol. xxii., pl. xiv., fig. 4.

that the various "eozoonal features" are the product of chemical or pseudomorphic changes in serpentine, initiated by structural disintegration, to which it is characteristically liable; and we have a legitimate right to use every evidence bearing out this view. Respecting the "fossil wood" illustration, the "disintegrated portions" of the case are totally without analogy; since, obviously, they do not *initiate* the "minute structures" alluded to. None of the arguments, or facts, we have brought forward to support our theory were derived from the examples of "Eozoon compressed, crushed, or partly destroyed by mineralization."

10th. We may be allowed to ask the reader to compare our detailed description of the grains of coccolite, and the mineral configurations, occurring in the Aker crystalline limestone,* with Dr. Dawson's mode of putting "objections" and "reasons" against them, to show that we have not been met in a way consistent with what is recognised in a scientific controversy.

11th. We fully expected when the occurrence of a "perfect canal system preserved in malacolite," and occupying the crevices in a crystal of spinel, from Amity, New York, became known to Dr. Dawson, that he would have procured specimens of the spineliferous rock at once. As this has not been done, and as there is nothing in the Paper under criticism to controvert this "remarkable case," we may assume it as completely demonstrative of the mineral origin of "Eozoon."†

12th. Dr. Dawson has "never been able to satisfy himself of the occurrence of any definite organic structure in the Connemara specimens of ophite:" moreover, considering our "tendencies," especially after we have adduced examples of true "nummuline layer" in cracks in this rock,‡ we do not expect that any statement of ours will meet with his acceptance. We would, however, ask Dr. Dawson—why he discards the detailed testimony of one of his co-believers, Professor T. Rupert Jones, who particularly mentions that the "Irish Green," as "shown to the practised eye," contains *every one* of the features diagnosed for "Eozoon Canadense"?§ Quite sufficient has been adduced to prepare the reader for Dr. Dawson's refusal to accept the "chamber casts," and their "aciculi," in Skye ophite, as eozoonal: our figure‖ is summarily set aside by the gratuitous statement, that it merely "shows granules of serpentine hispid with acicular crystals"! In our late paper on the Skye Ophite¶ an additional figure is given, representing a few "nearly parallel cylindrical processes" attached to the curving edge or surface of a piece of serpentine ("chamber cast"), and which, before decalcification, "traversed the carbonate of lime," forming

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* "Proceedings of the Royal Irish Academy," vol. x., pp. 546, 547.

† See Postscript.

‡ "Proceedings of the Royal Irish Academy," vol. x., pl. xlii., fig. 6; "Quarterly Journal Geological Society," vol. xxii., pl. xiv., fig. 4.

§ "Geological Magazine," vol. ii., pp. 88, 89.

‖ "Proceedings of the Royal Irish Academy," vol. x., pl. xliv., fig. 10.

¶ *Ib.*, New Series, vol. i., pl. xiv., fig. 5.

the "true cell wall." Five of the processes stand out conspicuously: three of the smaller ones are also conspicuous; but the remainder are obscurely defined. It is remarkable, that one of the largest is "slightly bulbose at the extremity"! As this example shows no appearance of "sharp angular needles radiating from a centre, or irregularily disposed," it must be taken to represent the "true cell wall." If our position is denied, Dr. Dawson will have to support himself by something more than mere gratuitous statements, or by weightier arguments than such as he is in the habit of adducing.

This ends our criticisms on every point which Dr. Dawson regards "as essential by way of explanation and defence of the organic nature of Eozoon." We would beg leave, however, to observe, that there are other and more essential points that have been overlooked. Possibly they may have been considered no better than the "multitude" which he felt "it would be impossible to enter into," and which we cannot help thinking may be related to those treated of in the concluding section of the present Paper.

Dr. Sterry Hunt, instead of treating of the mineralogical and chemical aspects of the question, as his special studies led us to expect, confines himself to "making a few criticisms" on the "views" we suggested to account for the mineral changes in serpentine, which, in our opinion, have developed the various "eozoonal features;" and hence his paper is remarkable for the absence of even the slightest allusion to the evidences and arguments we adduced to show, from their circumstances of occurrence, modifications, mineral and chemical characters, that these features are demonstratively of inorganic origin. Such absence is a fact, the significance of which we duly appreciate; and the full recognition of which we trust will not be hereafter ignored by those who believe in "Eozoon." Our theory, in many respects may be right, or it may be wrong: and although nothing more than a subordinate matter in the main question before us, we feel much pleasure in acknowledging that it has been correctly represented by Dr. Hunt in its principal points; and in having the opportunity of discussing it with him on the present occasion.

Dr. S. Hunt's ideas of pseudomorphism, it is well known, are at variance with those commonly entertained; while, to us, they appear to be in no respect in advance of the latter: indeed, in limiting the phenomenon to crystalline solids, they place him in some points in a retrograde position. Still, presuming he will not deny that serpentine occurs in the form of crystals belonging to amphibole, augite, olivine, &c., and that in such cases the serpentine must be a pseudomorph,—we would ask him, notwithstanding the chance of our being rebuked as extravagant pseudomorphists, if these instances ought not to be taken as evidences that rock masses (diorites, dolerites, olivenites), essentially composed of the minerals named, can be similarly changed? We need not dwell on cases of the kind:—one, the dolerite of Monzoni, was noticed

in our first memoir;* and others could be cited. But it would be some advantage to us to learn how such cases could be explained otherwise than by pseudomorphism *en masse*.

We are quite aware that it is usual to regard pseudomorphs as mineral substances, replacing others, and retaining their crystalline form; but we cannot believe that Blum, Bischof, and Dana, take this limited view. Examples do occur without any crystalline form remaining, especially when the change takes place in the external portions of the crystal; and certain minerals (chondrodite) seldom or never give rise to pseudomorphs in the form of crystals; while negative cases appear to be the absolute rule with serpentine. Now, such being the case with the latter mineral, how can we expect it to comport itself according to the general rule? And, to be particular, on what grounds are we to require calcite to occur as a crystal-pseudomorph after serpentine, when the latter *never* presents a crystalline form proper to itself? But, although such is the nature of serpentine, it seems to be quite overlooked that this mineral is common in the state of chrysotile, with a fibrous or asbestiform structure capable of being retained in the process of pseudomorphism. We have elsewhere made known examples of this variety, forming veins in ophite—parts of it here and there having been substituted by carbonate of lime, but still retaining the original fibrosity of the chrysotile.† Had nothing more than asbestiform carbonate of lime been present in the veins, no one would have suspected it to be a pseudomorph after serpentine.

If serpentine were an ordinary crystalline mineral, no doubt calcite would have occurred under the form of the crystal proper to it; just as it is found in the form of dodecahedrons that were once garnets,—of oblique prisms that were originally orthoclase, albite, oligoclase, or augite;‡ but usually occurring as an amorphous body, with the exception of the allomorph or variety just named, and some others of the kind, its replacing mineral is prevented from assuming any other than the non-crystalline condition. From what has come under our observations in the course of a prolonged investigation of the changes which serpentine undergoes, we have every reason for believing that much—probably all—of the calcite immediately associated with it in ophitic rocks is its pseudomorphic replacing substance.

It is simply from the rarity of non-crystalline cases that the rule has arisen of limiting the term pseudomorph to chemical replacements in the form of crystals. We cannot, however, be far wrong, especially when there are precedents in our favour, in extending the name to similar phenomena in amorphous or rock masses.

We may have "failed in showing," by our hypothesis, "why" serpentine has been replaced by calcite; but we can confidently appeal

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* "Quarterly Journal Geological Society," vol. xxii., p. 216.

† "Proceedings of the Royal Irish Academy," vol. x., pl. xliv., fig. 9, p. 531.

‡ "Dana's Mineralogy," 5th ed., pp. 272, 344, 361; Bischof, vol. ii., p. 315.

to our descriptions and figures of the cases adduced by us to show "that the calcite of the cell-wall of 'Eozoon' was once serpentine."* This is the true problem that was before us; and Dr. Hunt has not been able to show that our mode of solving it is any way unsound.

We think that Dr. Hunt has made more than was warranted of the fact that "both Rose and Bischof regard serpentine itself as the last result of the changes of a number of mineral species;" and that, according to the latter, it is "the very insolubility and unalterability of serpentine which causes it to appear as the final result." Bischof, as it appears to us, evidently intended his statement to be taken in a comparative sense, and not to be understood as meaning that serpentine is absolutely insoluble and unalterable; since he has repeatedly admitted that, under certain conditions, magnesian silicates are decomposed by carbonic acid,† and that serpentine itself may be decomposed by carbonated water.‡

With reference to the last point, silicate of magnesia is, comparatively speaking, a "stable" compound; but it has been too much overlooked by those who regard serpentine as a final product of pseudomorphism, that this mineral, besides containing a considerable percentage of water, is particularly prone to structural changes; as shown by its frequent fibrous and flocculent allomorphs—peculiarities eminently facilitating chemical substitutions: while it must not be overlooked the possible reaction between the calcite and serpentine, in ophite, at their contact surfaces, if water containing even a weak solution of carbonic acid penetrated into them—especially if the rock were situated at a great depth.

And as regards serpentine representing the last stage of pseudomorphism, we think insufficient attention has been paid to the fact that Bischof has qualified his view by the following remarks:—"The cyclical character which is generally recognisable in the alteration of minerals, suggests the question, whether those spoken of as final products of alteration, may not really be particular stages of wider cycles of alteration. It is *certain* there is *a limit to their duration.* It is very probable that the silicates of magnesia may, under certain conditions, *become the starting points* of other metamorphic processes. If the silicates of magnesia were dissolved, and carried away by water, they would also take part in the formation of new minerals."§ This implies the possibility of the removed serpentine being replaceable by another mineral substance. Considering that chrysotile, in the condition of a vein, has been changed into carbonate of lime, we may safely assume that the displacement of serpentine, followed by a replacement in calcite, is an established fact. By what precise mode the change has taken place—

* "Quarterly Journal Geol. Society," vol. xxii., pl. xiv., fig. 2, p. 192; "Proceedings Royal Irish Academy," vol. x., pl. xli., fig. 2, p. 315.
† "Chemical Geology," vol. i., pp. 2, 3; vol. ii., p. 123; vol. iii., p. 164.
‡ *Ib.*, vol. ii., p. 434.
§ "Chemical Geology," vol. ii., p. 113: slightly abridged. The italicization is our own.

whether by a direct, or an indirect process—is immaterial; but that it has been effected by some process of pseudomorphism is a conclusion which our investigations have placed beyond all doubt.

Two-thirds of Dr. Hunt's Paper are chiefly taken up with criticisms on our theoretical views, explanatory of the origin of the various "eozoonal features" by a process of pseudomorphic replacement. The other third is devoted to a *singular* explanation of the author's "view of the origin of limestones," and to the purpose of showing that we have formed a "misconception" of it. The view was simply adverted to by us in a foot note; and, being only collaterally connected with the subject of "Eozoon," we may be excused from going into it on the present occasion. We may observe, however, that the explanation *in no way modifies* our conception. Leaving out of consideration the origin of the cited "great beds of ancient marble," the azoic formation of which is enunciated in a manner unfortunately too common with Dr. Hunt, we contend that in the formation of marine limestones, both vital and chemical processes—the one primarily, and the other secondarily—have been concerned. The idea that such limestones have originated solely by chemical action, "without the intervention of life"—that their containing fossils is merely an "accidental occurrence"—reminds us of Dr. Hunt's "novel doctrine" of the direct chemical precipitation of serpentine from the water of the ocean. We have shown that there is nothing in Nature to support this doctrine; and, with the exception of fresh water and littoral travertines—whose chemical origin is easily explained by causes which it is difficult to understand could operate where ordinary limestones have been formed, that is, in marine depths—we feel satisfied that its author is quite unable to advance any cases of a really *apposite* nature to support his view of the origin of limestones.

We shall conclude this communication by briefly recapitulating the various points detailed in our previously published Papers, in order that the reader may readily become acquainted with the present aspect of the question discussed in these pages.

1st. The serpentine in ophitic rocks has been shown to present appearances, which can only be explained on the view that it undergoes structural and chemical changes, causing it to pass into variously subdivided states, and etching out the resulting portions into a variety of forms—grains and plates, with lobulated or segmented surfaces—fibres and aciculi—simple and branching configurations. Crystals of malacolite, often associated with the serpentine, manifest some of these changes in a remarkable degree.

2nd. The "intermediate skeleton" of "Eozoon" (which we hold to be the calcareous matrix of the above lobulated grains, &c.) is completely paralleled in various crystalline rocks—notably marble containing grains of coccolite (Aker and Tyree), pargasite (Finland), chondrodite (New Jersey, &c.).

3rd. The "chamber casts" in the acervuline variety of "Eozoon"

are more or less paralleled by the grains of the mineral silicates in the pre-cited marbles.

4th. The "chamber casts" being composed occasionally of loganite and malacolite, besides serpentine, is a fact which, instead of favouring their organic origin, as supposed, must be held as a proof of their having been produced by mineral agencies; inasmuch as these three silicates have a close pseudomorphic relationship, and may, therefore replace one another in their naturally prescribed order.

5th. Dr. Gümbel, observing rounded, cylindrical, or tuberculated grains of coccolite and pargasite in crystalline calcareous marbles, considered them to be "chamber casts," or of organic origin. We have shown that such grains often present crystalline planes, angles, and edges; a fact clearly proving that they were originally simple or compound crystals that have undergone external decretion by chemical or solvent action.

6th. We have adduced evidences to show that the "nummuline layer" in its typical condition—that is, consisting of cylindrical aciculi, separated by interspaces filled with calcite—has originated directly from closely packed fibres;* these from chrysotile or asbestiform serpentine; this from incipiently fibrous serpentine; and the latter from the same mineral in its amorphous or structureless condition.

7th. The "nummuline layer," in its typical condition, unmistakably occurs in cracks or fissures, both in Canadian and Connemara ophite.†

8th. The "nummuline layer" is paralleled by the fibrous coat which is occasionally present on the surface of grains of chondrodite.‡

9th. We have shown that the relative position of two superposed asbestiform layers (an *upper* and an *under* "proper wall"), and the admitted fact of their component aciculi often passing continuously and without interruption from one "chamber cast" to another, to the exclusion of the "intermediate skeleton," are totally incompatible with the idea of the "nummuline layer" having resulted from pseudopodial tubulation.§

10th. The so-called "stolons," and "passages of communication exactly corresponding with those described in *Cycloclypeus*," have been shown to be tabular crystals and variously formed bodies, belonging to

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* All that we have observed in connexion with the structural changes of serpentine in "eozoonal rocks," and the relations of this mineral to the adjacent calcite—whether occupying the narrow spaces between the aciculi of the "nummuline layer," or the wider ones between the "chamber casts,"—has led us to the belief that the latter mineral is a replacement pseudomorph after the former. Our interpretation of the facts, which have given rise to this view, has not been shown to be wrong in any respect.

† "Quarterly Journal Geological Society, vol. xxii., pl. xiv., fig. 4, p. 196; "Proc. Royal Irish Academy," vol. x., pl. xlii., fig. 5, 6.

‡ "Quarterly Journal Geological Society," vol. xxii., pl. xiv., figs. 5, 6, pp. 196, 197.

§ *Ib.*, vol. xxii., p. 191; "Proc. Royal Irish Academy," vol. x., p. 517.

different minerals, wedged cross-ways or obliquely in the calcareous interspaces between the grains and plates of serpentine.*

11th. The "canal system" is composed of serpentine, or malacolite. Its typical kinds in the first of these minerals may be traced in all stages of formation out of plates, prisms, and other solids, undergoing a process of superficial decretion.† Those in malacolite are made up of crystals —single, or aggregated together—that have had their planes, angles, and edges rounded off; or have become further reduced by some solvent.

12th. The "canal system" in its remarkable branching varieties is completely paralleled by crystalline configurations in the coccolite marble of Aker, in Sweden; and in the crevices of a crystal of spinel imbedded in a calcitic matrix from Amity, New York.

13th. The *configurations*, presumed to represent the "canal system," are *totally without any regularity* of form, of relative size, or of arrangement; and they occur independently of and apart from other "eozoonal features," (Amity, Boden, &c.); facts not only demonstrating them to be purely mineral products, but which strike at the root of the idea that they are of organic origin.

14th. In answer to the argument that as all the foregoing "eozoonal features" are occasionally found together in ophite, the combination must be considered a conclusive evidence of their organic origin, we have shown, from the composition, physical characters, and circumstances of occurrence and association of their component serpentine, that they represent the structural and chemical changes which are eminently and peculiarly characteristic of this mineral.‡ It has also been shown that the combination is paralleled to a remarkable extent in chondrodite and its calcitic matrix.§

* "Quart. Jour. Geol. Society," vol. xxii., pl. xiv., figs. 10, 11, pl. xv., fig. 15, pp. 207, 208.

† "Proc. Roy. Irish Acad.," vol. x., pl. xliii., figs. 7, 8, pp. 527, 528. Dr. Carpenter seems to be unable to give a correct account of our view of the origin of the "canal system." Speaking of its "arborescent structure" he has, on different occasions, stated that we "maintain it to consist of mere *mineral infiltrations*"! And hence, by adopting the following mode of reasoning, he evidently feels that a decisive case has been made out against us. As the "ramifications pass across the planes of cleavage, every mineralogist will at once say that this is perfectly conclusive— against their being, by any probability, mere inorganic infiltration; that nothing but organic structure could in this manner produce a ramification of one mineral in the interior of another, a ramification of serpentine in the interior of carbonate of lime passing against its crystalline planes" ("Pharmaceutical Journal," Feb. 11, 1871, p. 649). When this point was first introduced ("Quart. Jour. Geol. Soc.," vol. xxv., p. 118), we hinted to Dr. Carpenter that he was treading on, to him, unknown ground ("Proc. Roy. Irish Acad.," vol. x., *foot note*, p. 523); as it will necessarily follow, that imbedded minerals which produce "ramifications" in the "interior of calcite, and passing against its crystalline planes," (as is common with native silver, prismatic pyrites, &c.) can be "nothing but organic structures"! It is to be regretted that Dr. Carpenter does not altogether leave such points alone, or allow mineralogical believers in "Eozoon" to express their own arguments, if they have really got any.

‡ "Proc. Royal Irish Academy," vol. x., pp. 533, 534, 535.

§ "Quarterly Journal Geological Society," vol. xxii., pl. xiv., figs. 5, 6, p. 197.

15th. The "regular alternation of lamellæ of calcareous and siliceous minerals" (respectively representing the "intermediate skeleton," and "chamber casts") occasionally seen in ophite, and considered to be a "fundamental fact" evidencing an organic arrangement, is proved to be a *mineralogical* phenomenon by the fact that a similar alternation occurs in amphiboline-calcitic marbles, and gneissose rocks.*

16th. In order to account for certain *untoward* difficulties presented by the configurations forming the "canal system," and the aciculi of the "nummuline layer"—that is, when they occur as "*solid bundles*"—or are "*closely packed*"—or "*appear to be glued together*"—Dr. Carpenter has proposed the theory that the sarcodic extensions which they are presumed to represent have been "turned into stone" (a "siliceous mineral") "by Nature's cunning" ("just as the sarcodic layer on the surface of the shell of living foraminifers is formed by the spreading out of *coalesced* bundles of the pseudopodia that have emerged from the chamber wall")—"by a process of chemical substitution *before* their destruction by ordinary decomposition."† We showed this quasi-alchymical theory to be altogether unscientific.‡

17th. The "siliceous mineral" (serpentine) has been analogued with those forming the variously-formed casts (in "glauconite," &c.) of recent and fossil foraminifers. We have shown that the mineral silicates of "Eozoon" have no relation whatever to the substances composing such casts.

18th. Dr. Hunt, in order to account for the serpentine, loganite and malacolite, being the presumed in-filling substances of "Eozoon," has conceived the "novel doctrine," that such minerals were *directly* deposited in the ocean waters in which this "fossil" lived. We have gone over all his evidences and arguments without finding *one* to be substantiated.

19th. Having investigated the alleged cases of "chambers" and "tubes" occurring "filled with calcite," and presumed to be "a conclusive answer to" our "objections," we have shown that there are the strongest grounds for removing them from the category of reliable evidences on the side of the organic doctrine. The Tudor specimen has been shown to be equally unavailable.

20th. The occurrence of the best preserved specimens of "*Eozoon Canadense*" in rocks that are in a "*highly crystalline condition*" (Dawson) must be accepted as a fact utterly fatal to its organic origin.§

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* "Quarterly Journal Geological Society," vol. xxii., p. 210; "Proc. Royal Irish Academy," vol. x., p. 523.

† "Intellectual Observer," vol. vii., uncoloured plate, fig. 2, *a*, pp. 292, 294, 290; "Quarterly Journal Geological Society," vol. xxii., p. 222.

‡ "Quarterly Journal Geological Society," vol. xxii., p. 202; "Proc. Royal Irish Academy," vol. x., pp. 537, 538.

§ Dr. Carpenter, unable to defend himself against Mr. T. Mellard Reade's objection that "Eozoon" *only occurs in metamorphosed rocks* (*Nature*, No. 60), takes refuge under the *ad captandum* argument, that its "calcareous lamellæ" ("intermediate skeleton") "show less departure from the shelly texture than do the great majority of undoubted shells, corals, &c., contained in the least altered

21st. The occurrence of "eozoonal features" *solely* in crystalline or metamorphosed rocks, belonging to the Laurentian, the Lower Silurian, and the Liassic systems—never in ordinary unaltered deposits of these and the intermediate systems—must be assumed as completely demonstrating their purely mineral origin.

Considering how rapturously its advent into palaeontology was greeted by latter-day biologists, and others who were content to accept on mere authority a plausible yet one-sided explanation of a difficult problem, considerably beyond the ordinary means of proof, or disproof—considering, as is conclusively shown by the course of the discussions which have taken place since we first made our views public, that it can only be maintained by parrying, ignoring, misrepresenting, or futile attempts at refuting every counter argument and evidence urged from mineralogical, and other points of view*—the constructors of the "creature of the dawn" have certainly no grounds for exultation at its present position as a "received doctrine" in exact science.

Postscript.

The reading of the foregoing paper was followed by a short communication from Dr. Dawson, on "two points,"† which it is now necessary to notice :—

One relates to some fragments of Silurian crinoids, the "cells and tubes" of which are in the state of casts composed of "amorphous hydrous silicate of alumina and ferrous oxide, with some magnesia and alkalies," also, "angular and partially rounded grains of quartzose sand"—evidently a super-aluminous example of the widely varying mixtures, known as glauconite, green earth, &c. The case is interesting: but, never having denied the well-established fact that foraminiferal shells, corals, and other organisms occur with siliceous in-fillings of the kind—and having already determined the attempt to assimilate such substances with a certain class of minerals to be utterly unsupported by any proper evidences—we do not see the pertinency of introducing it (and some others made known last year by Dr. Carpenter,‡) into the

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rocks of any geological period" (*Nature*, No 62); forgetting that, as the substance of such fossils has undergone so much change, the fact demands a vast amount of metamorphism to convert the rocks containing them—"least altered" as they may be—into the "highly crystalline condition" of "eozoonal" ophite. But Dr. Carpenter seems to misunderstand the objection altogether; as it is not based so much on the mineral structure of the "eozoonal features," as on the fact that they occur best preserved in "highly crystalline" or metamorphosed rocks.

* We beg to refer the reader to two letters in *Nature* (No. 62 and 72) by Dr. Carpenter, especially the *last one*, in reply to the well-founded objections to "Eozoon" that have lately been put forward by Mr. T. Mellard Reade, as showing the arguments and tactics now adopted in defence of the organic doctrine.

† Proceedings, R I. A., New Series, vol. i., pp. 129-131.

‡ Quart. Jour. Geol. Soc., vol. xxvi., p. 415.

present discussion. Besides, it is altogether gratuitous, and inconsistent with scientific reasoning, to assume that the crinoidal in-filling "is similar to that effected by the ancient serpentine of the Laurentian" (Dawson); or, that it is "allied in the mode of its formation to the serpentine, pyroxene, and other minerals which have injected Eozoon" (Sterry Hunt).

The other relates to our statement of the occurrence of an essential "eozoonal feature" in connexion with a crystal of spinel, from Amity. We now learn that Dr. Dawson has had under examination specimens of spineliferous rock from the latter place:—and, notwithstanding his having pronounced the case as "*so unlikely*," the result is, that the specimens have been found to "contain in spots, remains of casts of canals similar to those of *Eozoon Canadense*." As to the inference that the specimens "are portions of a bedded rock, and not a vein stone"—without taking into consideration that it is suppositional, and based on an examination of specimens preserved *in collections*—it cannot set aside the plain fact, that in our specimen arborescent configurations—formed of groups of decreted crystals of malacolite, and identical with perfect and the finest examples of what are presumed to be "casts of the canal system"—are present in calcite, occupying the crevices of a large crystal of spinel. The fact of itself conclusively settles their purely mineral origin.

XXV.—On the Floatation of Sand by the Rising Tide in a Tidal Estuary. By Professor Hennessy, F. R. S., Vice-President of the Academy.

[Read April 10, 1871.]

During the course of a tour along our western coast, in the summer of 1868, the following incident came under my notice: and, although I made a note of the facts at the time, I have never hitherto made them the subject of a scientific communication:—

On July 26, when approaching the strand at the river below the village of Newport, County Mayo, I noticed what appeared to be extensive streaks of scum floating on the surface of the water. As it was my intention to bathe, I was somewhat dissatisfied with the appearance of the water, until I stood on the edge of the strand, and I then perceived that what was apparently scum, seen from a distance, consisted of innumerable particles of sand, flat flakes of broken shells, and the other small debris which formed the surface of the gently-sloping shore of the river. The sand varied from the smallest size visible to the eye up to little pebbles, nearly as broad and a little thicker than a fourpenny piece. Hundreds of such little pebbles were afloat around me, and it is probable that the flakes of floating matter seen farther off contained also a considerable proportion. The air during the whole

morning was perfectly calm, and the sky cloudless, so that, although it was only half-past nine, the sun had been shining brightly for some hours on the exposed beach. The upper surface of each of the little pebbles was perfectly dry, and the groups which they formed were slightly depressed in curved hollows of the liquid.

The tide was rapidly rising, and, owing to the narrowness of the channel at the point where I made my observations, the sheets of floating sand were swiftly drifting farther up the river into brackish and fresh water. On closely watching the rising tide at the edge of the strand, I noticed that the particles of sand, shells, and small flat pebbles, which had become perfectly dry and sensibly warm under the rays of the sun, were gently uplifted by the calm, steadily-rising water, and then floated as readily as chips or straws. I collected a few specimens of these little objects, but I regret that they have been since mislaid. This phenomenon, it is scarcely necessary to say, is due to molecular action, such as accompanies the familiar experiment of floating needles on the surface of a basin of water. Although the specific gravity of the floating objects exceeds that of the fluid on which they rest, the principle of Archimedes still holds good, because the displacement of liquid produced by the body is considerably greater than the volume of the body itself. In the case of a floating needle, the repulsion of the liquid from the polished surface of the metal presents a groove, whose magnitude is obviously many times greater than the needle; but in the case of the floating pebbles this was not so manifest. The specific gravity of needles made of fine hard steel may be taken at 7·9 nearly, while that of the little pebbles scarcely exceeds 2·6, so that other things being equal, the latter would require one-third of the displacement required by the former for perfect floatation. But, moreover, the small pebbles which I saw floating were always flat and thin, and rested with their broadest surface on the water. The attraction of the molecules of water for one another produces, as is well established, a tension at the surface of the liquid, which, although extremely feeble, and generally noticed only in connexion with capillary phenomena, yet interposes some resistance to the intrusion of foreign substances. This is seen in the experiment of floating broad spangles or sheets of dry gold-leaf on a vessel of water. When a piece of gold-leaf is held edgeways it sinks, and it also sinks if wetted. In fluids more viscid than water, such as lava or melted metals, flat pieces of the stone or solid metal are known to swim on their broad surfaces, while they sink when turned on their edges. I have recently made a few experiments on the floatation in water of small bodies of greater density than the liquid; and I find that needles have remained for days together floating. I have also easily floated sand, flat pieces of shells, and small pebbles for several days, and whenever they sank, it was due to some disturbance of the liquid sufficient to produce a wave on its surface. Mr. Alphonse Gages placed twenty-four needles

on the surface of a large basin of water, and after a few hours they were found grouped in parallel parcels, varying in their contents from two to seven needles. They continued to float for more than five days, and their sinking was evidently due to the progress of oxidation, which destroyed their polish, together with their repulsive action on the liquid. I have floated small flat pebbles, similar in size and appearance to the largest of those observed floating on Newport river, for more than six days, while fragments of shells, and thin pieces of slate as broad as a sixpenny piece, have continued to float much longer. These little bodies occasionally sank from the gradual absorption of water, but much more frequently from some accidental motion of the vessel containing the liquid.

It is manifest that the floatation of sand in a tidal estuary, as in the instance I have seen, can occur only under favourable conditions. The shores must be very gently inclined, the air perfectly calm, and the weather dry and warm. Under these circumstances thin cakes or sheets of sand may not only be uplifted by the water, but if the tide flows rapidly they may continue afloat sufficiently long to allow many of them to be drifted far from their original place up to the higher limit of the brackish water. In this way fragments of marine shells and exuviæ might become mingled with those belonging to fresh water. The conditions favourable for sand floatation must exist during calm weather in a very high degree of perfection on the sandy shores of tidal rivers in tropical and subtropical districts of the earth. As this phenomenon can take place only with the rising tide, and never with the falling tide, the result must generally be favourable to the transport of sand and marine *debris* in the direction of the flow of flood tide; and this may sometimes hold good along a coast as well as on the shores of a tidal estuary. Geologists, as far as I am aware, have not hitherto noticed this phenomenon in connexion with the formation of stratified deposits by the agency of tides and rivers, although they have paid great attention to the influence of the molecular resistance of water to the sinking of very minute solid substances, with the view of explaining the wide surface over which matter held in suspension by water may be spread when ultimately deposited over the sea bottom.

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* Since this paper was written I have been informed by a lady, that she observed similar phenomena during a former summer, close to the sandy seashore at Youghal.

XXVI.—Report on the Researches of Professor Cohnheim on Inflammation and Suppuration.* By J. M. Purser, M. B.

[Read May 8, 1871.]

As the result of his researches on inflammation, Professor Cohnheim thinks the two following propositions are established:—1. In an inflamed part the white corpuscles of the blood pass through the walls of the vessels in great numbers, and, having become free in the tissue, constitute the cells of pus. 2. The cells of the inflamed part itself have no share in the formation of pus; they persist for a time unchanged among the emigrated blood corpuscles, and if the inflammation last long enough, or attain a great intensity, they undergo a series of changes of a purely regressive or degenerative nature, ending in their death or destruction.

On the first of these propositions I have already reported to the Academy. The discovery of the passage of the leucocytes of the blood through the uninjured walls of the vessels, first made by our distinguished countryman, Dr. Augustus Waller, in 1846, and recorded in two papers in the "Philosophical Magazine" for that year, excited little attention at the time; and till the remarkable Paper of Professor Cohnheim was published in 1867, physiologists believed that all the cells found in the tissues, whether in the healthy or inflamed state, were formed *there* from *fluids* effused from the blood, either by a process of spontaneous generation (free cell formation) in this fluid or blastema, or by the division and multiplication of cells pre-existing in the part, and which were nourished by the effused blastema. But the re-discovery by Cohnheim that the passage of blood corpuscles through the vascular walls could be seen, and that the whole process of emigration could be watched and followed under the microscope, had the effect of disturbing the unanimity of opinion previously existing, and has given rise to a controversy as to the origin of pus corpuscles and other cells, which is still far from being settled. The great interest excited by the writings of Cohnheim has led to his experiments being repeated by numerous observers, and by these, with very few exceptions, his results, so far as they relate to the emigration of the leucocytes, have been confirmed.

In the Report already alluded to, I stated that on this point my observations were quite in accordance with those of Cohnheim, and since that Report was read I have many times repeated the experiments, and always with the same result. I have also had occasion frequently to demonstrate, to my pupils and others, the passage of the white corpuscles through the walls of the vessels. This phenomenon has been observed by

* Ueber Entzündung und Eiterung. Von Dr. J. Cohnheim. Archiv. f. path: Anat. Bd. XL. s. 1. Ueber das Verhalten der fixen Bindegewebskörperchen bei der Entzündung. Ibid. Bd. XLV, s. 333.

so many experimenters, that I think it may now be considered to rank as a thoroughly well established fact in physiology. As to the truth, however, of the second proposition believed to be proved by Cohnheim, opinions are not at all so unanimous. Whilst some writers, as, for instance, Billroth,* accept in their entirety the views of Cohnheim, and refuse to admit the proliferation of connective tissue cells, many other equally competent observers dispute the truth of these views; and while they admit that the white blood cells pass through the vascular walls, and form a part of the pus produced in inflammation, they still hold to the opinion supported by the great names of Virchow and Goodsir, that the greater part of the pus corpuscles is due to a multiplication of the cells of the inflamed part itself, and that the *role* played by the blood and vessels in inflammation is chiefly limited to the furnishing of increased pabulum to provide for the rapid growth and multiplication of the cells pre-existing in the diseased part.

Of the writings which have appeared in support of these latter views, the most noteworthy is a series of essays† by Professor Stricker and his pupils, in which are recorded the results of observations and experiments on the process of inflammation in the several tissues of both cold and warm-blooded animals, and in which it is stated that nearly every cell in the body, even those so highly specialised as the ganglionic cells of the brain, and the masses of protoplasm surrounding the muscular nuclei, can, under the influence of irritation and increased supply of nutritive material, multiply and give rise by repeated division to the moveable and indifferent (i. e. unspecialised) corpuscles of pus.

The observations of Cohnheim were made chiefly on the corneæ of frogs and rabbits, in which inflammation had been excited either by cauterising the centre of the membrane itself with nitrate of silver, or by putting a seton through the eye-ball behind the attachment of the cornea to the sclerotic. In the first case the cornea became primarily inflamed, in the second it suffered secondarily in the course of the panophthalmitis excited by the operation. As the result of either kind of treatment the cornea loses, after a time, its transparency, and becomes grey, and more or less opaque. If it be then submitted to microscopic examination, it is seen to be crowded with pus corpuscles which possess the highly refracting granular protoplasm, the multiple nuclei and the powers of spontaneous change of shape and position enjoyed by pus corpuscles in other parts. It is affirmed by Cohnheim, that besides these pus corpuscles the ordinary branched connective tissue cells of the normal cornea are also present, presenting no alteration from their natural condition, whether in their shape or arrangement, or in the character of their protoplasm and nuclei. If, indeed, the inflammation be very far advanced, so that the tissue of the cornea

* Henle and Meissner. Bericht, &c., 1869, s. 17. See also Billroth. Die allgemeine Chirurgische Pathologie und Therapie. Vierte Auflage, s. 66 *et seq.*

† Studien aus dem Institute für experimentelle Pathologie in Wien. Wien. 1870.

is softened, and that abcesses have formed in it, then the connective tissue cells show some changes of a purely passive kind such as a granular opacity of their protoplasm, a retraction of their processes and a formation of vacuoles in the interior of their cell-body; but in no case either of early or advanced keratitis is ever any appearance met with which could lead to the suspicion of a formation of pus corpuscles from the connective tissue cells.

As observations on the fresh cornea are difficult in consequence of its great transparency and the slight difference between the refractive power of the connective tissue cells and that of the intercellular substance in which they lie, Cohnheim recommends that the membrane should, before examination, be stained with chloride of gold. This most valuable reagent the knowledge of which, as applied to microscopy, we owe to Cohnheim, is used in the following way. The salt is used in solution of the strength of ½ per cent., made with distilled water, to which a few drops of acetic acid have been added. In this solution the perfectly fresh cornea is immersed for from ten to twenty minutes (the light being excluded), till it has acquired a distinctly yellow colour. It is then removed from the gold solution and placed in distilled water, to which enough acetic acid has been added to make it just sour to the taste, and submitted to the strongest sunlight which can be procured. After a time, varying from a few hours to some days according to the temperature and the intensity of the light, the cornea becomes of a reddish or purple colour from the reduction of the chloride of gold, and is fit for examination. The epithelium is scraped off its anterior surface, some radial cuts are made in its margin, so as to allow it to lie flat on the slide, and it is mounted in glycerine. The cornea of a small animal, such as a frog, may be mounted whole, that of larger animals has to be cut or torn into lamellæ parallel to the surface. In successful preparations, the corpuscles are seen to be stained of a colour varying from red through purple to almost black. The nerve fibres also to their finest terminations are similarly stained, while the intercellular substance is left quite uncoloured. The specimens may be examined with the highest powers and leave nothing to be desired in the beauty and distinctness of the appearances. Besides showing clearly the shape of the cells, this method makes their nuclei, which are not at all visible in the fresh condition, quite distinct, and it leaves the character of the protoplasm as it was in the living state, its more or less coarsely granular appearances being preserved. With the help of the chloride of gold Cohnheim confirmed his observations on the uncoloured tissue, and found, however numerous the pus cells might be in any part, that nevertheless the fixed cornea corpuscles continued to exist unchanged from their normal condition.

As the origin of pus from the connective tissue cells was thus excluded, two possibilities remained by which its presence in the cornea could be explained. It might be derived from the so called wandering cells by their division; or it might not originate in the cornea at all, but get into it from without.

The wandering cells discovered, and so named by Von Recklinghausen, were shown by him to exist in the healthy cornea in varying numbers. They perfectly resemble white blood or pus cells, and are found in all the connective tissues except cartilage. They possess power of spontaneous locomotion, and are hence called wandering, to distinguish them from the immoveable or fixed cells of the tissues. The idea that these wandering cells multiply by division, and so give origin to the corpuscles of pus is rejected by Cohnheim. He thinks that the irregular distribution of the wandering cells makes it very unlikely that they could by their proliferation produce the equable distribution of pus observed in keratitis, and he dwells on the fact that no one had ever seen a leucocyte divide, and that the supposed multiplication of pus cells by division was absolutely unsupported by direct observation. This, which was quite true when Cohnheim wrote, is so no longer. Stricker* has seen pus corpuscles divide in the tongue of the frog, and in the cornea of the same animal. Klein† has observed the same phenomenon in human white blood corpuscles and in those of the frog and triton, and I have seen it myself in the blood of the frog.

The second way of accounting for the pus cells in the cornea is by supposing that they do not originate in the cornea itself, but that they wander into it from without. That this is possible is proved by a beautiful experiment of V. Recklinghausen. A freshly excised cornea is placed under the skin of a living frog in one of the large subcutaneous lymphatic spaces, which in this animal separate the skin from the subjacent parts. At the end of some hours it is removed and examined, and is found to contain great numbers of moveable corpuscles, resembling in every particular those of lymph or pus. Besides these the stellate connective tissue cells are present in their ordinary form. The moveable corpuscles have therefore not originated in the cornea itself, but have crept into it from without, a fact which is still further proved by their being found at an early period of the experiment only at the edges of the preparation.

Cohnheim states that, as in the case just described, so after injury to the central part of the cornea in a living animal, the pus corpuscles get into the cornea from the edge. He describes how, after central cauterisation, the grey opacity, due to the presence of pus, commences to appear at the periphery of the cornea and gradually reaches the seat of injury, concentrating itself finally about this, while the peripheral parts become again clear. With the microscope the process can be followed by examining different corneæ at different periods after the infliction of the injury. At first the pus is seen only at the margin, and mostly at those parts which correspond to the insertion of the recti muscles, while the portion of cornea between this and the central eschar is unaltered. Then the region occupied by the pus extends towards

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* Loc. cit. s. 18 *et seq.*

† Henle and Meissner. Bericht, &c. 1869, s. 14.

the centre till it attains the seat of injury, and finally the marginal parts become again transparent and the stellate corpuscles are again seen as they were before the inflammation, and uninjured by the stream of leucocytes which has passed over them. An accumulation of pus corpuscles never *commences* around the seat of injury except in cases where the substance of the cornea has been opened either by the separation of a slough after cauterisation, or when a portion of the membrane has been excised or punctured. Under these circumstances a grey opacity is observed to form about the seat of injury and, extending centrifugally, to join that spreading centripetally from the margin. This is explained by the creeping into the cornea, through the loss of substance, of wandering pus cells from the conjunctival sac. But when the injury to the cornea has not been such as to open its substance, any cloudiness observed at an early period around the seat of injury is due, not to the presence of pus, but to a staining of the epithelium and intercellular substance by the caustic, and to the granular degeneration of the stellate fixed corpuscles.

Having by these observations proved that the corpuscles of pus did not originate in the cornea, but got into it from without, Cohnheim proceeded to investigate from what source they were derived—whether from the lymphatics or from the blood-vessels; and he concludes in favour of the latter for the following reasons. When finely divided particles of insoluble colouring matter are injected into the lymphatic sacs of a frog, and a keratitis subsequently excited, many of the pus corpuscles found in the cornea are seen to contain coloured granules; and this occurs whether the colouring matter is injected into a lymphatic space near the head or at a distant part of the body. Furthermore, it takes place if the colouring matter is injected directly into the blood, and in all cases after an injection into the lymph spaces, the white corpuscles of the blood are found in great numbers, containing coloured particles; and the latter, after a short time, are never found free in the blood or tissues, but always enclosed in leucocytes. As a still further proof that the pus comes from the blood, the following curious experiment is adduced:—A frog had a large vein opened, and through this the blood was completely washed out of his body, and replaced by a weak saline solution. After this operation Cohnheim has succeeded in keeping the animals alive for some days, and when, under these circumstances, the cornea was cauterised, no pus was ever formed, but the tissue remained clear and transparent.

A subsequent series of experiments was performed on the tongue of the frog with the same result. The pus was seen to be entirely derived from the emigrated white blood corpuscles, the connective tissue cells of the inflamed part undergoing no change.

This short and imperfect account of Cohnheim's investigations may give some idea of the beauty and ingenuity of the experiments. The pleasant and easy style in which the papers are written, and the novelty of the views put forth in them, make the whole subject one of peculiar interest; and I confess I went to work at it with a strong

feeling in favour of Cohnheim, and with almost a wish to find him right. I have, however, been quite unable to confirm his results, and I find it every day more and more difficult to understand how he could ever have observed the appearances which he records. My own observations have been made chiefly on the corneæ of frogs. I have examined also a great number of frogs' tongues. In these the connective tissue corpuscles are pale and difficult to see, and the field soon becomes covered with emigrated white blood cells, which increases the difficulty of observation. The tongue is, however, an admirable object in which to see the passage through the vascular walls of the leucocytes—indeed it was in it that this phenomenon was first observed by Dr. Waller. The best mode of examination is that recommended by Cohnheim. The animal is poisoned with a small dose of *curara*, and, when motionless, laid on his back on a large slide, on which a raised piece of glass of suitable size and shape, and surrounded by a margin of cork, has been cemented. The tongue is drawn out of the mouth and laid on the piece of glass, and fastened by small pins to the cork. A small piece of the mucous membrane is clipped off one part of the tongue with curved scissors. This causes hardly any bleeding, and as it is the papillary surface of the tongue which is now uppermost, the removal of the mucous membrane greatly increases the transparency of the object. The tongue may then be submitted to examination with high or low powers. If it shows any tendency to dry, it may be moistened with a weak saline solution, or with artificial serum; but this is rarely necessary. The phenomena observed in the tongue are described by Cohnheim as precisely similar to those seen in the cornea. The white corpuscles pass out through the vascular walls, and the connective tissue cells remain quite unaltered throughout the process. Stricker has, however, seen the pus corpuscles, whether emigrated from the vessels or formed outside, multiply by division; and he has observed an active movement of the connective tissue cells. I have frequently seen the markings described by Stricker as appearing on the leucocytes prior to their division. I have, however, never observed the complete separation of one corpuscle into two. This I attribute mainly to the great difficulty I have found in keeping the circulation in the tongue perfectly normal during the prolonged examination necessary to observe the inflammatory process. Our frogs are certainly less well adapted for physiological experiments than those used on the Continent, and very many of my experiments have failed, I believe, in consequence of the feebleness and low vitality of the animals I had to employ.

I proceed now to detail the results I have obtained by my observations on the inflamed corneæ of frogs. In these the inflammation was excited either by cauterising the centre of the cornea with a fine point of nitrate of silver, or by passing a thread through the bulb behind the corneo-scleral junction. Some specimens of spontaneous ulcerative keratitis (a disease from which captive frogs very frequently suffer, particularly in the summer months) were examined, and in some instances the inflammation was induced by drawing a seton through the

cornea itself. The corneæ were excised and examined at intervals varying from a few hours to eight or ten days after the infliction of the injury; sometimes in the fresh condition in the moist chamber and immersed in aqueous humour or some other indifferent fluid, sometimes after staining by chloride of gold or carmine.

In all cases the changes observed were essentially the same in kind, but infinitely variable in degree. A condition which in one animal was produced in a few hours, would in another require two or three times as long for its production, and this without my being able to explain the delay by any unusual condition of the animal under experiment. Furthermore, in very few instances was the inflammatory process equally advanced in all parts of the same cornea, but parts at the same distance from the point of irritation were found at all stages of the inflammation in widely different states; and in many cases, in different parts of the same specimen, all appearances could be seen, from a tissue swarming with pus corpuscles, and presenting no other formed elements, to one in which the normal condition of the cornea was scarcely departed from. I shall therefore say very little of the time required for the production of each stage in the formation of pus. In all instances this time was in my hands greater than that found necessary by German experimenters, a fact which I attribute to the greater feebleness of our frogs to which I have already alluded.

I may state at the outset that I have found in no single instance the state of things described by Cohnheim. In no case have I seen the connective tissue corpuscles of the cornea lying unaltered amidst the pus cells. In every case, *pari passu* with the appearance of pus, the connective tissue cells disappeared, and hence, while in no way denying the immigration of white corpuscles from without, I am fully convinced that the great mass of the pus corpuscles are formed in the cornea itself from the connective tissue cells. It will be the object of the remainder of this report to describe the forms intermediate between these two kinds of cells.

Passing over a slight, and not always very evident, swelling of the connective tissue cells, the first very marked change which we observe in these is a tendency to become elongated in one direction. They thus lose their equally stellate shape, and while the processes or rays at the two sides are drawn in, those at the ends may persist for some time. The nucleus accommodates itself to the shape of the cell, and assumes also an elongated form. The protoplasm is at this period more granular than in the healthy cell. The tendency of the cornea corpuscles to become more or less spindle-shaped when irritated, and after the removal of the irritation, to resume their natural form, has been known since the publication of the beautiful researches of Kühne* on the protoplasmic movements of animal cells. When the irritation is very

* Untersuchungen über das Protoplasma und die Contractilität. Von Dr. W. Kühne. Leipzig, 1864, s. 121 *et seq.*

severe and persistent as in our case, the corpuscles do not recover their stellate form, but undergo still further changes.

In the next stage of the inflammatory process the cells have completely lost their primitive form and have become perfect spindle, or club-shaped bodies. Their protoplasm has become granular and more highly refractive than that of the normal cells, and examined in the fresh condition, spontaneous changes of shape can frequently be observed in it. The cells now usually contain more than one nucleus. I have counted as many as seven in one cell, and three or four are very common. They are round or oval, with a variable number of nucleoli, and are sometimes visible in the fresh condition, but become much more distinct after the addition of reagents. They often lie at considerable distances from each other, and the cell is not uncommonly constricted between two of them. The appearances at this stage are often very beautiful. The spindle-shaped cells lie with the greatest regularity, those of one plane crossing at right angles those of the next. They are best seen in cases where the inflammation has been excited by passing a seton through the eye-ball, for, where the cornea has been directly irritated, the inflammatory process proceeds so much more rapidly that, mixed with the spindles, are generally seen a great number of perfect pus corpuscles, and so the regularity of the picture is lost.

That these spindle-shaped bodies are developed from the stellate cells of the cornea is plain, for the following reasons. We have already seen that the stellate cells, without losing their characteristic appearances, show a marked tendency, at an early stage of the inflammation, to become elongated, and this is observed first at those parts of the cornea where subsequently the true spindles are first to appear, viz.:—at the periphery when the bulb has been traversed by a thread, and in a zone surrounding at some distance the eschar when the centre of the cornea has been cauterised. As the spindles appear the stellate cells disappear, and where the regular arrangement of spindles described exists, few or no stellate cells are to be found. This occurs often within twenty-four hours or less after the commencement of the experiment, long before any disappearance of the normal cells by degeneration could have taken place, and while in other parts of the cornea these bodies are scarcely altered from their normal condition. Lastly, in some of the spindles two kinds of nuclei occur; one that already described, the other resembling very closely that of the stellate cells. This latter is smoother, flatter, and less refracting than the other more common kind. It is difficult to describe these appearances, but they are perfectly distinct, particularly in chloride of gold preparations, and cannot be mistaken by any one accustomed to examine objects of this nature.

How the nucleus of the spindle, which closely resembles that of the pus corpuscle, originates from the nucleus of the stellate connective tissue cell, I am unable positively to state. The invisibility of the nuclei in the fresh condition would make it impossible to actually observe the change taking place; but I think there can be little doubt that, with the more coarse granulation, in most cases, a process of division occurs.

The next stage consists in the division of the spindles. A constriction between two nuclei has already been mentioned, and in this way a spindle assumes a biscuit or hour-glass form. One cell frequently divides across several times, and then we find a row of cells evidently all derived by division from one parent, the whole group retaining the spindle form, and reminding us forcibly of the similar groups of cells in cartilage.

The spindles, however, often do not retain their shape until they divide; but with the multiplication of nuclei, they assume an irregular outline, and form moveable multi-nucleated masses, which have been particularly described, and admirably figured by Stricker and Norris.* They are best seen in cases where the cornea itself has been injured, and where the whole process of suppuration runs a more rapid, and, so to say, less orderly course than where the keratitis is merely a part of a general inflammation of the eyeball.

The spindles or multi-nucleated masses having broken up, we have the pus corpuscles fully formed with their active movements and powers of spontaneous locomotion, and the process, so far as the suppuration is concerned, is complete. There are, however, other appearances met with in inflamed corneæ which it is necessary to notice. Frequently a cell is seen which still retains its stellate form. It is, however, enlarged, its processes are thicker and shorter than natural. It still possesses its normal nucleus; but in addition to this it contains one or more other nuclei, similar to those of the spindles, or of pus corpuscles, and these lie in a part of the protoplasm which is much more coarsely granular than the remainder of the cell. These are real well-defined nuclei, and are not merely dark spots in the protoplasm, such as are often seen in normal cells,† and which somewhat resemble the pigment masses in the glanglionic cells of the brain and spinal cord. Again, one of the processes of a stellate cell is swollen and rounded at the extremity, and the protoplasm in its interior is granular and refracting. There can be little doubt that these cells finally divide and give origin to pus corpuscles, probably after having become irregularly-shaped, many-nucleated masses, like those which originate from the spindles. Such is, I believe, the process of suppuration as it occurs in the cornea, but it must not be supposed that the stages are passed through as regularly as they have been described, and that, at a given moment, elongated corneal cells alone are to be seen, at another spindles only, and at another pus. At every stage, on the contrary, almost every form is to be seen, and this greatly increases the difficulty of understanding the appearances. A very few minutes after the application of the caustic an increase in the number of the wandering or pus cells is to be noticed, an increase so rapid that I think it can be explained only by assuming an immigration from without; and at the most ad-

* Loc. cit. s. 9. Taf. I. fig. 3.

† Compare the drawings accompanying Lipmann's Paper on the Terminations of the nerves in the cornea, in Virchow's Archiv.: Bd. XLVIII., s. 218. Taf. VII., figs. 1-4.

vanced periods some few stellate cells persist, which from some unknown cause, refuse to proliferate. Still the general course of the inflammation is, I believe, as I have described it, and in favourable specimens the different stages can be clearly traced, sometimes existing separately in different regions, sometimes co-existing in the same part.

It will thus be seen that the main point on which Cohnheim relies in support of his theory must be given up, and that in an inflamed cornea the stellate cells do not remain unchanged or merely degenerate, but that they undergo changes of an active kind, terminating in their multiplication and division into pus corpuscles.

This point being given up the other parts of the argument are of little importance and may be dealt with briefly.

With regard to the part of the cornea in which the suppuration commences, I have also to differ from Cohnheim. When the bulb is traversed by a thread the changes commence, as was to be expected, at the periphery and extend towards the centre. But when the centre of the cornea is cauterised the suppuration commences in a zone surrounding the eschar, and separated from it by a more or less considerable interval. This zone, which may be called the zone of proliferation, is separated also from the margin of the cornea by a border which at first contains only a few pus corpuscles, and which, at a time when nearer the centre pus is fully formed, often contains only spindles or stellate cells. The zone of proliferation appears to approach the margin first at the upper and lower parts of the cornea, and this is due I believe partly to the intra-corneal pus meeting here the stream of immigrating leucocytes, and partly to the fact that here the large blood-vessels approach the cornea, and the membrane receives not only the largest number of wandering cells, but also the freest supply of nutritive material, and is consequently able to produce pus most rapidly.

The presence of cells containing coloured granules in the inflamed cornea after an injection of the colouring material into the blood or lymph is not of much importance. The number of such cells is quite insignificant compared to the total number of pus cells in the cornea, and their presence merely shows, as Stricker remarks, that under favourable circumstances blood corpuscles may leave the vessels and wander into the cornea, a fact which, I believe, has never been denied in this discussion.

I have often seen leucocytes containing coloured particles in the cornea, but I have never seen the colouring matter free or contained in the stellate cells. This, however, has been observed by Recklinghausen, Stricker,* and Hoffman, and Langerhans,† but I think it must be admitted that the vast majority of the coloured particles have been brought into the cornea by the wandering cells in whose interior they are seen.

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* Loc. cit. s. 14.

† Ueber den Verbleib des in die Circulation eingeführten Zinnobers. Archiv. f. Path. Anat. Bd. XLVIII. s. 313.

With regard to the degenerative changes observed by Cohnheim in the cornea corpuscles, I have not much to say. I have very seldom noticed in the cells the formation of vucuoles on which he places so much stress. Stricker has found this phenomenon to be more common in the summer months than in the colder part of the year, but he has also observed movements in the vacuolated cells which make him believe that they are not so dead and degenerate as Cohnheim supposes.

Nitrate of silver exerts an influence on the cornea extending to a considerable distance beyond the point touched by the caustic. This is seen by the absence of suppuration immediately around the eschar, and by the fact that corneæ irritated with nitrate of silver in general stain well with chloride of gold only at the margin. In the part about the cauterisation the stellate corpuscles can be seen for some time retaining their normal shape. What becomes of them subsequently I cannot say, but I believe they take no part in the formation of pus. The intercellular substance of this altered region presents sometimes a wavy fibrillar appearance, obscuring the cellular elements altogether; at other times it remains homogeneous. The breadth of this passive portion of the cornea is very variable, depending probably on the severity of the cauterisation, and its extent determines the distance from the central eschar of what I have called the zone of proliferation.

The usual fate of a cornea in which inflammation has been excited in one of the ways mentioned, is to soften and burst. This is, I believe, invariably the case when a thread is passed through the eye, and the irritation is thus persistent. But from some facts I have observed, I am led to believe that after cauterisation the cornea may recover itself even after extensive suppuration, and that this recovery takes place by the reformation of spindles from the pus cells, and the formation of a kind of fibrous tissue. The steps of this process, and whether the normal structure of the cornea is ever completely restored must be matter for further investigation.

Those acquainted with the researches of Professor Stricker on inflammation, will perceive that the results at which he has arrived agree very closely with those put forth in this report. I had quite satisfied myself of the main points contained in this communication before I saw Stricker's papers, and I was much gratified at finding so close an agreement between his opinions and mine. I feel myself, however, much indebted to the writings of Professor Stricker and his pupils for having directed my attention to many minor matters which I should possibly otherwise have overlooked.

XXVII.—On Optical Saccharometry, with special reference to an Examination of some Specimens of Sugar Beet grown in Ireland. By John H. Jellett, B. D., President.

[Read May 22, 1871.]

Referring to a paper read before the Academy some time ago by Dr. Apjohn, having for its object the determination of the amount of each of three kinds of sugar contained in a given syrup, the author said that his present object was to describe to the Academy the method of using for this purpose an instrument which he had formerly exhibited to them, and an account of which is published in the "Proceedings" for 1863.

The method is as follows. Three observations are necessary to be made with the optical instrument:—

1. The tube of the saccharometer being filled with the syrup to be examined, and the compensating fluid being French oil of turpentine, let the reading of the scale be l_1.

2. The syrup having been subjected to the usual process for inverting the cane sugar, and the tube of the saccharometer being filled with the syrup so inverted, let the reading of the scale, corrected for the dilution of the syrup in the process of inversion, be l_2; the compensating fluid being an aqueous solution of cane sugar, 100 grains to the cubic inch.

3. The tube of the saccharometer is filled with the solution of cane sugar, used in (2), diluted with two parts of water. This dilution is necessary, inasmuch as the solution employed in (2) is too strong to be within the range of the instrument. Then, the compensating fluid being French oil of turpentine, as before, let the reading of the scale be l_3. Let l be the length of the tube of the saccharometer, and let c, i, g be the quantities of cane, inverted, and grape sugars respectively. Let also C, I, G be the rotatory power of these three sugars, and F the rotatory power of French oil of turpentine; then we have from (1),

$$l\,(Cc - Ii + Gg) = Fl_1 \qquad (1)$$

from (2),

$$l\,\{(c + i)\,I - Gg\} = 100\ Cl_2 \qquad (2)$$

and from (3),

$$100\ Cl = 3Fl_3 \qquad (3)$$

It is to be observed that all three sugars are reckoned throughout this investigation as if they had the same atomic weight as cane sugar, so that it will be necessary to augment the values found for the inverted and grape sugars in the ratio 171 : 198.

Dividing now (1) by (3), and putting

$$I = KC,\ G = K'C,$$

we have

$$c - Ki + K'g = \frac{100 l_1}{3 l_3}; \tag{4}$$

again dividing (2) by C we have

$$K(c + i) - K'g = \frac{100 l_2}{l}.$$

Adding these equations, we have the amount of the cane sugar given by the equation

$$(K + 1)c = 100\left(\frac{l_1}{3l_3} + \frac{l_2}{l}\right),$$

and substituting this value in (4),

$$K'g - Ki = \frac{100\left(\frac{Kl_1}{3l} - \frac{l_2}{l}\right)}{K + 1}$$

These equations, combined with that obtained by means of Barreswil's solution, are, as was shown by Dr. Apjohn for Soleil's instrument, sufficient for the solution of the question—when the coefficients K, K' have been previously determined.

It may be well to mention some precautions which are necessary for the success of this experiment:—

1. It has been shown that the amount of cane sugar can be found by the optical method alone, without the aid of the copper solution. The truth of this conclusion, however, depends on the identity of the temperature in the first and second experiments. If the temperature be not the same, I will have different values in (1) and (2), and it will be no longer possible to determine the amount of the cane sugar by the optical method alone. Now, it may often happen that the determination of the cane sugar is the only point of practical importance in the investigation. It is therefore desirable that the experiments (1) and (2) should be made at precisely the same temperature.

2. It is known that the rotatory power of a solution of grape sugar, when freshly made, is greater than that of a solution which has been allowed to stand for some time. This power, however, may be reduced to its *minimum* value by heating the solution to 180° Fahr., and then allowing it to cool. It is therefore necessary to heat to the same temperature the given syrup containing the mixture of the three sugars, in order to reduce to a fixed value the rotatory power of the grape sugar which it contains.

The author also laid before the Academy the result of an examination of some specimens of sugar beet, grown on the Glasnevin Model Farm. These specimens were treated as follows. A portion was cut from each root by planes passing through the axis. This was grated on a coarse grater, then steeped in spirit ($G = \cdot 828$), and pressed in a screw press. The residue was again treated with spirit, and pressed; and this process was repeated. The expressed fluid, the spirit having been distilled off at low pressure, was made up to a known bulk with water, and filtered through animal charcoal, the first portion of the filtrate being rejected. The fluid thus obtained was examined in the way described above. The amounts of cane sugar in 100 grs. of the root are as follow:—

		Total Weight of Root.	
		lbs.	oz.
1	12·03	1	$12\frac{1}{4}$
2	9·56	1	14
3	12·57	1	14
4	12·60	2	–
5	11·62	2	7
6	12·43	1	$13\frac{3}{4}$

XXVIII.—REPORT ON THE MOLECULAR DISSOCIATION BY HEAT OF COMPOUNDS IN SOLUTION. By CHARLES R. C. TICHBORNE, F.C.S., M.R.I.A., &c. With Plates XV. and XVI. (Science).

[Read April 24, 1871.]

PART I.—INTRODUCTION.

M. DEVILLE's researches upon the dissociation of compounds by heat, when converted into the gaseous condition, have brought prominently before us the antagonistic nature of thermal to chemical force.* We find that the antagonistic action of these forces is manifested when we are dealing with compounds in the liquid condition, or in the so-called "solutions" of solid substances. It is a commonly acknowledged idea that in such cases heat hastens and modifies chemical decompositions; but how it modifies them? and to what extent? are questions which are seldom clearly defined.

The main purport of this report is the application of such inquiries, as those mentioned, to the science of chemical geology. I may remark, that some of the hypotheses mentioned in the course of my Paper, are generally acknowledged, some indirectly accepted, and some emanate from myself. Similar remarks will apply to the phenomena observed.

* The modifications of force are for convenience considered in this Paper as separate entities.

To specify, or enter too fully into these niceties, would needlessly encumber my report with extraneous matter; and I have therefore determined to leave such points to the reader's discrimination, except in a few special cases.

We may have various phases of decomposition, according to the force with which the molecular fragments of a compound are held together; and it is immaterial whether we consider such bodies as built up by the direct addition of molecules or by substitution. Compounds of a complex nature must be viewed as an aggregation of perfect entities, capable of having an individual existence; but these component molecules cannot be taken into account when we are considering the more complicated molecule—e.g., morphia splits up, on the application of heat, into apomorphia and water—no one could for a moment suppose that the molecule H_2O existed as water in the morphia, as its removal radically changes all the properties of the resulting compound. The more complex molecule has peculiarities which are not common to its factors, and *vice versâ*.

The importance of a study of such points in connexion with chemical geology is almost self-evident; but I may as well state that in this report the subject has been merely considered from a chemical point of view. The surface of the earth has been, and is, undergoing superficially a rapid change from its primitive condition of igneous construction. This change is continuously going on, and growing more and more profound. In this metamorphosis, water may be considered as the prime mover towards the ultimate results of the chemical as well as the physical arrangement of our earth's surface. Such a line of study is as invaluable as it is difficult; and it will be my endeavour, more to open up this line of research than attempt to master even a moiety of such knowledge.

Compound molecules exist as solids, liquids, and gases, provided that the temperature necessary to convert them into these physical modifications is not above the temperature at which their components are dissociated. The application of heat to a molecule may be graphically, although perhaps rather fancifully represented by the annexed figure :—

———————— | α —— —— —— — - | β - - . . . .

Solid. | α Liquid. | β Gaseous.

Now, we can easily conceive that a substance A may be of sufficient structural stability to pass through all the increasing vibratory action without dissociation of its component molecules, until it has passed through the solid, liquid, and far into the vaporous condition, whilst a substance B has, what I will call, a thermanalytic point, or the point where the equilibrium upon such a line is broken. If it lies between α or β, we have dissociation in the liquid condition. A great number of compounds are dissociated above the point β (e.g., anomalous

vapour density of chloride of ammonium), whilst those dissociated between α and β are less common, and are much less easy of observation.

Of course the following broad rules may be accepted:—1. The greater the temperature the greater the number of molecules capable of dissociation, or the greater the tendency to dissociation; and on the contrary, the lower the temperature the greater the molecular stability. 2. The more complicated the construction of the molecule, the lower the temperature at which dissociation commences; and after disruption, the higher the temperature necessary to carry on further dissociation of the residual molecule. 3. As a corollary, it follows that examples of dissociation by heat in liquids, or of solids in solution, are comparatively uncommon; but that when such phenomena do occur, they materially affect ordinary reactions, and that, *ceteris paribus*, decompositions at one temperature will not, of a necessity, correspond with those affected at another temperature.

In aqueous solutions, and at ordinary pressure, all molecular dissociation must occur under 100° C., that is to say, within the boiling point of the fluid in which the substance is dissolved. Under pressure, however, from the increased range of temperature, extraordinary phenomena may be induced, and thus heating in sealed tubes offers facilities for producing decompositions that cannot be brought about at ordinary temperatures.

Dissociation of compounds in solution, unless accompanied by some ocular demonstration, is apt to be overlooked, from the simple fact that the molecules rearrange themselves generally in the same form on cooling, and thus the change is transient. Frequently, however, *in mixtures*, a dissociation is accompanied, on cooling, by a re-arrangement of the two, or more groups of molecules, according to the altered affinities. The statical condition having been once broken, a different arrangement may take place.

I may illustrate the phenomena to which I have referred in the introduction by the consideration of a few of the most simple cases.

None are more common than dehydration. The molecules, H_2O, in such cases, forming the crowning particles of complicated structures, are held thereto with but a feeble force, and are easily dissevered even in solution. Lime water is a familiar instance, and although it has not, that I am aware, been demonstrated, there can be little doubt that the precipitate got on boiling that fluid is due to dissociation of the molecule of water, or its dehydration, thus—the action of heat upon the hydrate of lime ($Ca''O, H_2O$) is to produce $Ca''O$, and H_2O.

$Ca''O$, being insoluble in water, or very much less soluble than its hydrate. This is probably what takes place. The insolubility is, however, concurrent with the rise in temperature.

As there do not seem to be any experiments extant, except the original ones of Dalton, the subject was considered sufficiently im-

portant to verify, as they bear upon an investigation to be ultimately embodied in this report.*

Experiment I.:—

A saturated solution of lime was formed in the following manner: Freshly burned lime was slacked and washed by decantation—distilled water being used—the residual lime was then digested with fresh water for twenty-four hours, with occasional shaking. This, on subsidence, constituted the lime water used. It is hardly necessary to observe, that all this manipulation was carried on in a stoppered bottle. The bright lime water was poured off into a flask, this was brought quickly to the boil, and whilst boiling poured upon a filter arranged in the following manner:—A glass funnel was placed inside a double funnel of tin, the outer space of this double funnel being filled with glycerine, which was kept as near the boiling point as practicable. (The boiling point of "Price's Glycerine" is about 177°—182° C.). By this means the lime water is kept as near to the temperature of dissociation as possible during the whole of the draining and drying, which is only a matter of about half an hour. Hydrate of lime dried over sulphuric acid does not suffer loss on being submitted to a similar temperature. The precipitate was brushed into a platinum crucible and weighed; it was then ignited, and the loss calculated.

In two determinations the weighings showed a considerable reduction; but in both cases this was much under the quantity required by a true hydrate.

Thus—

	Weight of Precipitate.	Loss on Ignition.	Percentage H_2O. Theory.	Percentage H_2O. Practice.
First determination, . .	·155 gramme, . .	·031 . . .	24·33 . . .	20
Second determination, .	·131 „ . .	·023 . . .	— . . .	17·56

It is curious to observe that the 2nd determination gives the amount of loss required by the formation of a hydrate having the composition 3 $Ca''O$; 2 H_2O, viz., 17·64. This experiment was executed as rapidly as possible.

* The following quotations are taken from most of the recent authorities, and are all evidently based upon the original experiments of Dalton, published in 1810 ("A New System of Chemical Philosophy, Part II., by John Dalton, Manchester"). Dalton gives lime water formed at 60° Faht., as containing 1 grain in 778 grains of water, and at 212 Faht., 1 grain in 1270. "Watt's Dictionary of Chemistry," vol. 1, p. 718, says, "Hydrate of lime is more soluble in cold than in hot water, hence water saturated with lime in the cold, deposits the *hydrate when boiled.*" Miller says, in his "Elements," Part 2, p. 418, 4th edition, "Lime is soluble in about 700 parts of cold water. . . . . . If lime water, saturated in the cold, be raised to the boiling point, half the lime is deposited." Wurtz, in his "Dictionnaire de Chimie," quotes Dalton's experiments, and says, "*La chaux est peu soluble dans l'eau et elle présente cette particularité qu'elle l'est plus à froid qu' à chaud,*" &c.

In the above experiment the only point that was satisfactorily established was the fact, that a dehydration really does take place, and that the molecule H_2O is, to a certain extent, torn from its chemical position, even in the presence of an excess of water, and that it is not due to any specific insolubility of the hydrate at 100° C.

Experiments 2, 3, and 4 were to determine the solubility of lime at different temperatures. Chemically pure carbonate of calcium was prepared by dissolving the precipitated commercial preparation in hydrochloric acid, and treating the resulting solution with sulphide of hydrogen and filtering. The filterate was then allowed to digest with a slight quantity of ammonia, and again filtered after warming. A few drops of sulphuric acid were added, and it was allowed to stand twenty-four hours before filtering from the precipitated sulphates. From this solution the carbonate was prepared with the aid of carbonate of ammonium. The well-washed carbonate was ignited in a platinum crucible, until it no longer effervesced on the addition of dilute hydrochloric acid. Having procured what might be considered as pure lime, the next point was to determine its solubility at different temperatures, in the following manner:—

Experiment II.—*Determination of the Solubility at* 15·5° *C.*:—

After standing upon an excess of lime for some days in a silver flask, a lime water was procured by decantation. For twelve hours before pouring off it was rigorously maintained at a temperature of 15·5 C. 4000 grain measures were operated upon in each determination. In the two last determinations the lime water was filtered in an apparatus by which as much as possible of the atmospheric carbonic anhydride was excluded. I am of opinion that these last determinations give the results as a little under the mark; but I am also of opinion that decantation probably gives it over; for these reasons the average of the three experiments has been taken. The estimation was made with a volumetric solution of sulphuric acid, 100 degrees of which would neutralize one equivalent of a monevalent element:—

			Degree of vol. solution.
First	determination	(decanted), ...	20
Second	do.	(filtered)	19
Third	do.	,, ...	18·9

Therefore, as $19{\cdot}3\ \frac{Ca''O}{200} = 5{\cdot}404$ grains of lime present in 4005, so 1 grain of lime, or its equivalent of hydrate, requires 741 grains of water at 15·5° C.

Experiment III.—*Determination of the Solubility of Lime at* 100° *C.*:—

A small copper boiler was used in this experiment, which was provided with a valve to regulate the pressure, and a thermometer to indicate the temperature in the interior.

Through the top of this boiler passed what may be described as a kind of Beals' "filter." It consisted of a glass tube, bent at right angles, one of the ends of this tube being moulded into a bell-shaped mouth, which mouth was tied over with a piece of Swedish filtering paper, and over this again a piece of muslin, which might be also placed upon the other side, if great pressure were going to be used. By this arrangement, although the orifice presented a perfect filtering medium, it would stand a considerable amount of pressure. This end was submerged about half way into the boiler, which was filled with pure lime water, procured as in the previous experiment. The other end of the tube was provided with a glass stop-cock. The stop-cock was closed, and the lime water rapidly brought to the boil. On allowing the valve to exert a slight pressure in the interior, and opening the stop-cock slightly, the lime water slowly flowed out, the pressure in the interior being just sufficient to force the lime water through the bibulous paper, and up the capillary tube. The thermometer would occasionally go up a degree, but this was at once remedied, by opening the valve. When a sufficient quantity of water had been collected in this manner, the amount of lime was estimated as in the previous experiment.

In two determinations 3002 grains consumed 8 degrees of the vol. solution $8 \cdot \frac{Ca''O}{200} = 2 \cdot 24$ grains lime present, or 1 in 1340.

Experiment IV.—*Determination of the Solubility at* 109° *C.*:—

This experiment was performed in exactly a similar manner to the previous one, except that the valve was so placed that it blew off at a pressure corresponding to a temperature of 109° C. 3000 grains, obtained in this manner, consumed 6 degrees of the volumetric solution of acid; $6 \cdot \frac{CaO''}{200} = 1 \cdot 68$ grains of lime in solution.

These results may be tabulated as follows:—

One Part of Water at—	Takes up of Ca'' O—
15·5° C.,	$\frac{1}{741}$
100·	$\frac{1}{1340}$
109·	$\frac{1}{1785}$

and so on, until a point would be reached at which lime would practically be insoluble.

* Dalton's experiment upon this subject are in his "New System of Chemical Philosophy," Part 2; Manchester: 1870. They are as follows:—"When water of 60° is duly agitated with hydrate of lime, it clears slowly, but a quantity of lime water may soon be passed through a filter of blotting-paper, when it becomes clear and fit for use. I found 7000 grains of this water required 75 grains of test sulphuric acid for its saturation. Consequently, it contained 9 grains of lime. If a quantity of this, saturated with water mixed with hydrate of lime, be warmed to

The dissociation of water from lime seems peculiar to many of its compounds, and seems connected with the dismorphism of carbonate of calcium. See calcite and arragonite, p. 190.

The determination of the solubility of lime at different temperatures are of importance in connexion with this report, because, independently of its geological bearing, it affords a simple but illustrative example of the dissociation of compounds generally when in solution.

In this example we have the combined molecule H_2O becoming separated in the presence of an overwhelming excess of water from the dissociative influence of heat. The gradual character of the action is also strikingly illustrated, the dissociation being in ratio to the increment of temperature, and is, under ordinary circumstances, only stopped by having arrived at the maximum temperature of water at the pressure of the atmosphere.

The phenomena, however, is capable of further extension under increased pressure *ad infinitum*. The laws of molecular dissociation by heat have been only studied as far as regards volatile substances, but these laws seem applicable to the solution of substances modified by the altered physical condition, and are in their phenomena very similar. Thus, in speaking of gaseous dissociation, in connexion with the laws of Avogadro and Ampère, M. Wurtz* makes the following remarks :—

"Un des meilleurs arguments qu'on puisse invoquer en faveur de cette interprétation est celui qui est tiré de la densité de vapeur du Bromhydrate d'amylène. C'est une combinaison liquide du carbure d'hydrogène amylène avec l'acide bromhydrique—Portée à une tempèrature peu supèrieure à son point d'ebullition cette combinaison montre une densité de vapeur qu'on peut appeler normale, parce qu'elle répond à 2 volumes de vapeur pour 1 molecule. La vapeur est intacte à cette temperature, mais qu'on la chauffe, elle va éprouver une décomposition plus ou moins complète, suivant que la chaleur fournie aura été plus ou moins considerable . . . . Mais cette décomposition est graduelle ; elle ne s'achève pas à un degré fixe, mais entre des limites de température assez etendues, de telle sorte que la vapeur, intacte à un certain degré, se trouve melangée, à des degres plus élevés, avec des portion de plus

180° and then agitated, it soon becomes clear. 7000 grains of this water decanted require only 60 grains of test sulphuric acid. The same lime water was boiled with hydrate of lime for two or three minutes, and set aside to cool without agitation; it very soon cleared—7000 grains being decanted require only 46 grains of test sulphuric acid to be neutralized, the test-acid being, as usual, 1·134. Hence we deduce the following table :—

One Part of Water,	Takes up of Lime,	Hydrate of Lime.
60° Faht.,	$\frac{1}{778}$	$\frac{1}{584}$
130° ,,	$\frac{1}{972}$	$\frac{1}{720}$
212° ,,	$\frac{1}{1270}$	$\frac{1}{952}$

* Histoire des Doctrines Chimique, par Ad. Wurtz, p. 79.

en plus notable de ses produits de décomposition, jusqu'à ce qu'enfin la temperature s'etant élvée encore, la décomposition se trouve achevée. A ce moment, la densite de vapeur est descendue à la moitié de ce qu'elle était d'abord. Peut-on en conclure que le bromhydrate d'amylène offre deux densités de vapeur? Il est évident qu'il ne saurait en être ainsi, et il est naturel de penser que la vraie densite de vapeur est celle qui a été déterminée à une temperature assez basse pour qu'on soit en droit de supposer que la molécule est encore intacte. Que si cette densite décroit avec la température, cette circunstance est due a l'action décomposante que la chaleur exerce sur la vapeur."

Again, in speaking of the exceptions to the laws of Avogadro and Ampère, he says:—

"Deux molécules, capables de prendre chacune la forme gazeuse, sont réunies par l'affinite en une molécule plus complexe. Il peut se faire que le point d'ebullition de celle ci soit situé assez bas pour que la chaleur fournie pour la mettre en vapeur ne restitue pas aux deux molécules primitives la chaleur qu'elles avaient perdue en s'unissant; elles demeurènt alors en combinaison. Mais peut-on s'attendre à ce qu'il en soit toujours ainsi? et l'affinite de deux corps l'un pour l'autre ne peut-elle pas être assez faible, ou le composé qu'ils forment assez peu-volatil pour que le point de dêcomposition soit situé au-dessous du point d'ebullition?"

Substances in solution must behave in a similar manner to those in a gaseous condition, except that in such cases it is only the more loosely combined molecules that are affected at ordinary pressure; but still we cannot conceive that there could be any limit to this decomposition under extraordinary pressure, such as would be exerted subterraneously.

We know that compound structures are capable of being separated piece-meal, e. g. a compound alum. The molecules are removable, commencing with the water of crystallization, and ending with its most ultimate molecules. Thus let us take the trimethylamine alum,* a well defined compound exactly similar in general construction to ordinary alums ($C_3H_{10}N, Al'''$; $2SO_4$ $12H_2O$). We see at once the great number of molecular points of dissociation it is capable of being divided into, beginning with the first 10 molecules of H_2O that, according to Gerhardt, are removable at 120° C. or ending with $\left.\begin{matrix}CH_3\\CH_3\\CH_3\end{matrix}\right\} N$.

Hertwig says the molecules H_2O are removable in three instalments. How far the action of heat is capable of splitting up this structure when in solution resolves itself into a question of pressure. But

* There being no practical line of demarcation between what is known as "organic substances" and "inorganic substances," as regards the laws of dissociation, examples taken from organic chemistry are *en rapport* with the objects of the Paper.

it will be seen further on that on the application of heat to such a compound as an alum it reacts upon all the more unstable parts exactly as if they were not grouped together in the first instance, and that the whole structure is if anything lowered as regards its thermanalytic point, and thus weakened by its complexity. As the components are removed the residue has more stability.

The molecules known under the term "water of crystallization" are but slightly removed from the water of "hydration," and but slightly removed from the water of solution; frequently the alteration of a few degrees of temperature is sufficient to convert one into the other.

The water in the salt seems to be in a crystalloidal condition, but as a colloid in the other case. The crystalloidal water even in solution frequently is capable of dissociation, and of apparently changing its condition—such changes produce the phenomena of supersaturated solutions. The phenomenon of solution is a demonstration of force, and of actual combination between the molecules of water, and the substances dissolved. But if the more intimate unions be taken, it is evident that in such cases as hydration, or water of crystallization, the molecules that we recognize as H_2O are playing different functions, or are in a different condition to the water of solution.

In an octahedral crystal of ammonia alum, water is almost essentially the geometrical solid, and is as important as the alumina, ammonia, or other elements.

If this alum be dissolved by applying heat, it is split up into a substance—which is no longer alum geometrically or chemically, although we have got conventionally into the habit of saying it has "dissolved in water," or it has "dissolved in its water of crystallization," as the case may be. It is not only decomposed, but requires some little time for the molecules of water to regain their accustomed position or crystalloidal condition. So that they may be assimilated into the edifice—as illustrated by the following:—

Experiment V:—

A saturated solution of the ammonio-ferric alum was poured upon a small quantity of the crystals of the same salt, and a few drops of acid added to prevent the precipitation of a basic salt. It was quickly brought to the boil, and then allowed to remain at rest until it had regained the original temperature, 15° C. Although the solution had a thermometer frequently inserted and withdrawn, there was no indication of crystallization, until some three to four hours had elapsed. Now under the ordinary rules of solubility, these crystals should begin to form immediately that the thermometer reached 15° C. This phenomenon is exhibited by all the hydrated soluble salts in some degree.

A very interesting and remarkable group of molecules are the basylous trioxides, of which, however, we need only consider three. These three are $Al_2'''O_3$, $Cr_2'''O_3$, and $Fe_2'''O_3$ oxides, which perform a very important part in our earth's crust, and possess well-known

properties in common. The first and last alumina and ferric oxide are, perhaps, the most important substances of the mineral world, if we except silica and lime. There is a wonderful analogy between all their compounds, and they all possess in common a less degree of molecular stability, from complexity of construction, and, *ergo*, a corresponding susceptibility to the action of heat, when in solution. The minerals formed from these bases frequently take a form common to the colloidal base.

M. Debray has lately published some ingenious observations upon the action of heat upon one of these solutions—namely, the ferric salts.* As my own experiments, however, have led to rather different results, I have simply given my own experience, and feel less delicacy in doing so, from the fact, that my investigations in this direction were well known, and have a prior date to those of M. Debray. I exhibited some experiments upon the dissociating influence of heat on these solutions before the Dublin Chemical Club in 1867.†

This dissociation is well-marked in the ferric salts, by the colour of their solutions. All the ferric salts are nearly colourless, or have, perhaps, but a very faint lemon tinge. It is probable that if we could get the tri-salt in solution without decomposition, a perfectly colourless liquid would be the result.

Experiment VI. :—

Ferric chloride, obtained by passing chlorine over iron filings heated in a porcelain tube, was dissolved in a moderate quantity of pure water (free from ammonia), a dilute solution of hydrochloric acid was then added, drop by drop, until the minimum point of coloration had been obtained. The iron was then estimated by precipitation with ammonia, and the chlorine by nitrate of silver. The following figures represent the result obtained :—

	Practice.	Theory, per cent.
Fe, ...	33·91	34·46
Cl, ...	66·09	65·54

This slight increase in the amount of chlorine is evidently due to the basylous action of the water: and chromatic neutrality of such salts is dependent upon the amount of dilution, and is in a certain sense independent of the chemical neutrality. A chemically pure salt, when dissolved, gives a slightly basic solution, depending upon the relative volume of the water it is dissolved in.

Experiment VII. :—

The further addition of acid produced a darkening of the solution, which had previously been rendered as neutral as practical. Therefore, both acidity and basicity produce colour in these solutions.

Heat applied to ferric solutions gives an intense darkening in ratio to the temperature employed. It is almost certain, as will be seen from the experiments detailed, that the first action of the heat is the

* "Comptes Rendus," April. 1869.

† Minutes of the Dublin Chemical and Philosophical Club, 1867.

dissociation of crystalloidal water, and then the splitting up of the structure into a basic salt, and free hydrochloric acid; and that the dissociation may be carried ultimately so far as to result in the total splitting up of the structure. These results do not, however, agree with M. Debray's conclusions. Presuming that there is no other disturbing cause, the molecules regain their original arrangement of structure on cooling; but time becomes an important element here—the time required being in ratio to the extent of dissociation. The preparation of the ferric salts used was effected in the following manner:—A neutral persulphate was formed in the moist way, preference being given to this method to that first adopted—namely, that of making the chloride obtained by sublimation, the starting point.

To a weighed quantity of ferrous sulphate dissolved in water, the requisite proportions of nitric and sulphuric acids were added by the aid of volumetric solutions carefully adjusted. The salt was evaporated to dryness, at about 80° C., and, after powdering, was kept for some days at a temperature of about 75° C. This powder, when thrown into water, slowly dissolved in the cold, giving a slightly tinged and basic solution, which required the cautious addition of weak sulphuric acid. The addition of chloride of barium to this salt, in equivalent proportions, gave also a neutral solution of ferric chloride, &c.

Experiment VIII.:—

A concentrated solution of ferric sulphate was submitted to a temperature of 100° C., the solution gradually became darker during the increment of heat; but there was no evidence of precipitation.

Experiment IX.:—

The above solution was rather copiously diluted, and on being reheated, it gave a basic precipitate of a yellow character, which contained sulphuric acid. Placed under the microscope it was seen to consist of semitransparent and *crystalline masses*. By long and continued boiling a precipitate was procured in a concentrated solution.

Experiment X.:—

The basic precipitate procured in the above experiment was sealed up in the liquid in which it was found, and occasionally agitated. After the lapse of some considerable time it re-disolved, with the formation of the original salt. To ensure success it is necessary that the boiling in the first instance should not be carried too far, and that the fluid be not too much diluted. A similar tube, tied upon the beam of a steam engine, to ensure constant and energetic agitation, gave the same results in two days.

Experiment XI.:—

The addition of alkaline salts to the ferric compounds determines more easily the precipitation, or dissociation. Therefore, the iron alums, either with ammonia, or potash, exhibit this phenomenon in a marked degree. These alums, which show a beautiful but very faint amethyst tint, gave, on solution in the cold, a slightly-coloured liquid, made paler on the addition of a very dilute solution

of sulphuric acid. The gradual increase of temperature brought about all the reactions and phenomena observed in the above experiments, only in a much more marked and decided manner; whilst again this lowering of the thermanalytic point was even more evident with the potash alum.

It is unnecessary to detail the experiments performed with the solutions of ferric chloride, because the results were almost the same. I would wish, however, to observe that, even on prolonged boiling, there seems to be little or no loss of HCl, *at ordinary atmospheric pressure.*

It having been determined that the first results of a continuous boiling of a neutral ferric salt is the precipitation of a basic salt, containing but a small part of the stylous element, further experiments were performed to determine how far these acid molecules were removable at ordinary atmospheric pressure, by the combined and continuous action of water and heat.

Experiment XII.:—

A large quantity of a diluted solution of ferric sulphate was submitted to continuous boiling until a considerable precipitate was obtained. This precipitate was collected upon a filter, washed once, and dried at 100° C. ·219 gramme, gave ·141 of ferric oxide when dissolved in HCl, precipitated with ammonia, and weighed after ignition. This corresponds to 64 ·4 per cent. of ferric oxide. A portion of this precipitate, before drying, was placed in a considerable body of water, and again submitted to a temperature of 100° C. for two hours. After this treatment the appearance was much changed. The colour, which was originally of a light ochrey-yellow, had been changed to a reddish-brown, whilst the precipitate became much denser; ·338 gramme now gave ·32, on precipitation, as in the previous estimation, and, therefore, corresponds to 82·5 per cent.; it however, still contained a trace of the basic salt. The further action of heat upon these basic salts will be found described in Experiment XIV.

It must be borne in mind that all the above experiments had been performed with what we might call chemically neutral salts, but it is probable that from a geological point of view there would be formed $Fe_2''' \frac{2a''}{3}$ or a deficiency of one-third of the acid, e. g. from the oxidation, for instance, of iron pyrites. In such a case we would have to start with a basic solution, the first result of the oxidation of the pyrites being a ferrous salt, which ultimately becomes oxidized into the ferric. *Vide* remarks, p. 181.

Experiment XIII.:—

To a weighed quantity of pure crystallized ferrous sulphate a quantity of pure nitric acid was added, sufficient to exactly oxidize the ferrous salts to its higher term. The acid was allowed to remain in contact with the powdered salt without the addition of water, until on dissolving a portion, and after warming and

testing with ferricyanide of potassium all trace of the magnetic salt had nearly disappeared. This product was then diluted with fifty times its weight of water—such a solution is perfectly clear, and will remain so for some little time; but ultimately it decomposes spontaneously at ordinary temperatures, the time being determined by the amount of dilution and temperature. When diluted so as to represent ·5 per cent., a given volume *a* of this liquid gave on precipitation with ammonia, and on ignition, 1·557 gramme of ferric oxide. In a second determination, the solution was brought to 100° C. and maintained at that temperature for some time; the precipitate that fell was separated from the liquid by filtrations, washed with a small quantity of water, and dissolved in hydrochloric acid, and the oxide estimated in this solution with ammonia, as in the first instance—·559 gramme was procured, which is over the amount of base really in excess of the acid present $\frac{a}{3} = \cdot 519$ gramme. The filtrate again on dilution, and boiling gave a precipitate representing ·049 gramme of oxide. The filtrate again on dilution and boiling became opaque, but it was not necessary to follow out this experiment further—it being evident that there was no actual limit. It is probable that many of the ores, such as hæmatite, brown iron ore, bog iron ore, ochres, &c. are formed in somewhat a similar manner to that detailed, and it is curious to observe that sulphuric acid is seldom absent from such as are hydrated, and frequently in much larger quantities than the published analyses would lead one to suppose. *Vide* analyses, p. 190.

We have now to consider the action of heat upon such fluids under pressure.

Experiment XIV.:—

*A solution of ferric sulphate was placed in a tube of hard german glass,** and hermetically sealed. This tube was then placed in a gun metal apparatus capable of bearing a considerable pressure. A little water being placed in the apparatus to equalize the pressure outside the glass tube, the heat was gradually raised until a thermometer, the bulb of which was placed in a cavity outside the apparatus, marked 177° C. The whole apparatus was maintained at this temperature for two hours; on cooling and taking out the tube, it was seen that a similar decomposition had taken place as that obtained under ordinary atmospheric pressure, only in a more marked manner; at the bottom of the tube there was a considerable precipitate of an ochrey nature, consisting of basic sulphate, but at the surface of the fluid there was an incrustation, composed of red oxide of iron, adhering to the side of the tube in the form of a ring.

Experiment XV.:—

Was a modification of the previous one; but in this case

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* It is necessary in these experiments to have a good glass, as some specimens of lead glass seem to be rapidly acted upon at high temperature by many of the solutions used.

a more volatile stylous element was chosen, and although it was placed in a tube as in the previous experiment the orifice was left unsealed. We were, therefore, on placing it in the apparatus described above, submitting the fluid to the action of a considerable volume of steam at a pressure of nine atmospheres. After two and a half hours' digestion the contents of the tube presented a remarkable appearance. The greater part of the iron lay at the bottom of the tube, not in the form of a basic precipitate, but as a dark and heavy oxide of iron. Thin layers of this oxide adhered to the tube at the surface of the fluid, which when examined by the microscope were seen to be transparent and brilliantly red; by reflected light they possessed a blackish metallic lustre. The tube still contained an acid salt of iron, which however no longer acted upon the enclosed oxide; the latter seemed anhydrous.

In the first experiment (Exp. XIV.), there can be no doubt that a similar change had partially taken place; but only to a slight extent; it was the limited volume of steam generated in the tube reacting upon the surface of the fluid that formed the ring of ferric oxide. Certain specimens of specular ore (analysis 4) are formed in this manner; they are simply pseudomorphs of the sublimed and anhydrous ferric chloride produced by volcanic agency, and ultimately submitted to the action of high pressure steam.*

Experiment XVI.:—

The basic precipitate procured upon boiling a solution of ferric sulphate at ordinary temperature was next placed in a tube with a little water, and submitted to the action of steam for two and a half hours at a temperature of 177° C. The result was the gradual conversion of the precipitate, which lay at the bottom of the tube to the extent of about fifteen millimetres, into a bright red and dense precipitate, which, however, gradually assimilated its original appearance until, at the depth of six millimetres, it appeared to have retained its primitive composition and ochrey appearance. Some considerable proportion of this precipitate seemed to have been carried up the side of the tube; at the line of juncture of steam and fluid this precipitate was converted into anhydrous oxide of iron—above this the basic salt was intact, except that it seemed to be perfectly dehydrated and white, and it was not until it had been in contact with the fluid contained in the tube, that it seemed to regain its original appearance. It is evident, therefore, that as regards the more fixed and non-volatile acids no dissociation is effected at the temperature tried, except in the presence of condensed water, but that the steam is capable of removing water of hydration under such conditions.

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* In speaking upon this subject, in his Lectures on Chemical Geology, Dr. Percy says,—" Supposing we have the vapour of sesqui-chloride of iron, there is no difficulty in accounting for the formation of this sesqui-oxide in volcanic regions. If that vapour be brought in contact with the vapour of water, we get a deposit of crystallized sesqui-oxide of iron, with the formation of hydrochloric acid.

Before disposing of these experiments, I should wish to draw attention to some speculations upon this subject which have been promulgated by Dr. Percy in his lecture on Chemical Geology:*—

"It" (ferric oxide) "is found pseudomorphous after iron pyrites; it is a puzzle to know exactly how this pseudomorphism has taken place. If iron pyrites is exposed to the weathering action of the air, it is converted, and must be converted, first of all, into a common sulphate of protoxide of iron. That becomes oxidized by exposure to the air passing to the state of a sulphate of sesquioxide of iron. That sulphate of sesquioxide of iron, by the action of water, decomposes into two salts—an acid salt, which will dissolve away, and a more basic salt which would remain. We can easily understand the transformation of iron pyrites under these conditions into a highly basic sulphate, and even into hydrated sesquioxide, because we have only to call into our aid bicarbonate of lime, which frequently occurs in mineral waters. The trace of sulphuric acid might be easily removed, and the gypsum formed washed away, leaving nothing but hydrated sesquioxide of iron in the manner described, and then exposed to a certain degree of heat, whereby the water of the hydrate may be expelled, and the red oxide left. But that theory will not suffice, because we find certain crystals of hydrated sesquioxide of iron which are partially converted on the outside into red oxide of iron. It is perfectly evident that the temperature sufficient to decompose the hydrate could never have existed when such crystals were formed, because, if it had, it is impossible to conceive that any nucleus of hydrated sesquioxide of iron should remain. The formation of this anhydrous sesquioxide of iron in nature is yet unexplained satisfactorily. We can produce it readily enough in our laboratories by means of heat, but there is no reason for supposing that in the condition in which it has been produced in nature, a high temperature has prevailed, or at least that remark applies to many cases of the formation of that mineral."

As regards the ultimate removal of the sulphuric acid, it would seem, from the experiments detailed, that it is not absolutely necessary to call in the aid of a second base, such as lime, it being quite possible and probable that the same results may be obtained under the laws of dissociation by the aid of immense pressure and a long period of time, such as would be at work in geological changes.

Again, as we see that we can have perfect dehydration even in the presence of water or steam, the second difficulty which presents itself in the crystals of anhydrous oxide, containing the nucleus of hydrate, is disposed of, and is explained by Ex. XVI.

The chromic oxide behaves exactly in a similar manner, except that, *ceteris paribus*, the point of dissociation is higher, and therefore it requires more careful investigation to observe the changes produced by

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* "Chemical News," vol. IV., p. 147.

heat upon its compounds in solution, which, so far, have escaped observation, or have been misconstrued.

It is well known that the ordinary chromic salts present a peach blossom colour when in solution, convertible by heat into green solutions. The most natural of the many explanations given of this phenomenon is one of dehydration. But there is something more than this. Theoretically it would seem that it was this—that the chromatic change was due to basicity of the solution as in the ferric salts, and that it was only necessary to increase the boiling point of the solution by pressure, or to increase the basicity by the volume of water, to obtain similar results to those obtained with iron. This was satisfactorily verified by many experiments, a few of which will suffice to illustrate this part of my subject.

Experiments XVII. *and* XVIII. :—

Solutions of chromic sulphate and potassio-chromic alum, when submitted in tubes to a temperature of two to three hours in the pressure apparatus, gave in each case basic precipitates—the temperature being 177° C. The precipitate in the last-named substance being very voluminous, I did not succeed in procuring anhydrous chromic oxide corresponding to the ferric oxide, but look upon its consummation as merely a matter of pressure.

Experiment XIX. :—

A dilute solution of any chromic alum, if dropped into a flask of boiling water, is instantly dissociated. The contents of the flask become quite opaque, and the basic precipitate is palpable to the eye. This precipitate is redissolved on cooling, and even during boiling, if the solution of chromic alum is added in any quantity.

If we accept the theory—of which there can be little doubt—that there can co-exist a basic and an acid salt in solution, this explains at once the change of violet salts of chromic oxide into green solutions on boiling. Any neutral salt of chromic oxide dissolved in the cold gives a violet colour contaminated with green ("peach blossom"?). This, as in the iron salt, is due to the basylous action of the water. The cautious addition of dilute sulphuric acid converts it into nearly a pure violet. It is converted into the green solution either by the addition of an alkali, by the addition of water, or by heat. In other words, the green colour in chromic salts is due to the basylous condition. In the case of heat, the green solution regains, after some time, its original condition, but only slowly. Many explanations have been given of this phenomenon, and it seems almost strange that so simple a one should have escaped observation.

The aluminic oxide also obeys the same law of dissociation, only in a still less marked manner. It was evident that from analogy this should be so, although at the first glance it would appear that such was not the case. But, on taking into consideration the relative atomic position of the elements concerned, it would be seen that dissociation could be only exerted at ordinary pressure to a very limited extent as regards this base; thus there is no evidence of decomposi-

tion in solutions of any considerable strength on boiling; but if a very considerable proportion of water is there to the amount of salt, a basic compound thereof is precipitated at 100° C. This is best seen by passing a beam of electric light through the flask, as the precipitate formed is almost optically invisible in daylight. A beam of electric light impinging upon the light flocculent precipitate at once reveals its existence. It is almost absolutely necessary to use some such light when operating upon chloride of aluminium; but an aluminic alum, by virtue of the extra play of affinities brought to bear, gives a reaction easy of observation by the eye. These precipitates redissolve on cooling. As regards the effects of extraordinary heat procurable under pressure, we find that alumina behaves in a similar manner to the other members of this group, which the following experiment will illustrate:—

Experiment XX.:—

The ammonia and potash alums were placed in separate sealed tubes, and submitted for two and a half hours to a temperature of 177° C. White crystalline precipitates were produced, varying in composition, but containing sulphuric acid. They represented the greater part of the alumina present.

Experiment XXI.:—

. An open tube containing a solution of chloride of aluminium was placed in the same apparatus (described in the iron experiments), and submitted for some hours to a temperature of 177° C. At the line of juncture of fluid and steam, a white colloidal substance was deposited, which seems to consist of a mixture of hydrated and anhydrous alumina. This experiment throws some light upon the formation of corundum. Sapphire, ruby, and topaz, have been formed artificially with perfect success by Ebelmen, Deville, and others. All these artificial processes, however, have been igneous ones. In nature, however, it is evident that the corundum is not always, if it is ever, formed in this manner. It frequently contains from 3 to 4 per cent. of water, and is also associated with diaspore, and other hydrated minerals.

Before concluding this part of my report, I will consider for a moment the results of these experiments collectively. It would seem that the compound molecules of aluminic, chromic, and ferric oxides, are dissociatable in ratio to their atomic weight, or we may say, as regards this group, that their basylous position is in ratio to their dissociatability. Thus, although compound alumina molecules are dissociatable at ordinary temperatures, when insufficiently dilute, the decomposition is not so well marked until we get an extraordinary pressure, and a corresponding increase in the range of temperature. Again, that in the presence of other compounds of basylous elements they are more easily dissociated from the introduction of a second basylous molecule reacting upon the acid. The following series of experiments upon the alums and simple salts will place what is stated in a clearer light. Some of them were performed by taking very diluted but standard solutions of

the typical salts, and adding degree by degree to them, whilst in a state of ebullition, water, until the thermanalytic point was reached; they were so arranged that the evaporating water was recondensed, and flowed back into the flasks. The water was distilled twice, the first time from a small quantity of acid-sulphate of potassium, to render it free from all trace of ammonia. The flasks were made of hard German glass, and were digested with dilute hydrochloric acid for some time before they were used. It was found impossible to obtain water by filtration through paper that would stand the test of a beam of the electric or lime light. The clearest water was obtained by subsidence after distillation from a silver retort. Except in a few cases, most of the experiments can be followed by performing them by gaslight. The flasks must, in this case, be carefully cleaned, and a powerful gas-flame be placed opposite the manipulator and behind the flask. The faintest precipitate will be perceived by this means, on holding the flask close to the eye, providing it is not of that peculiar transparent and colloidal nature sometimes observed in modifications of alumina and silica.

The solutions used were weak, but were so proportioned that each contained an equivalent quantity of the trioxide to correspond to one gramme of chloride of aluminium, dissolved in the half litre of water. The exceptions were in two of the iron experiments. The following were the results:—

Experiment.	Salt used.	Weight used, or equivalent to one gramme of Al_2Cl_6 in $\frac{1}{2}$ litre H_2O.	Temperature at which dissociation sets in.	Degrees, cubic cent., of dilution required to produce decomposition with 1 gramme Al_2Cl_6 or its equivalent.
22	$FeNH_4 2SO_4,12H_2O$.	3·597	53·5° C.	9·5 C. C.
23	..	With one vol. more H_2O.	48	
24	..	With two vol. more H_2O.	43	
25	$FeK2SO_4$, $12H_2O$.	3·753	50° C.	8· C. C.
26	..	With one vol. H_2O.	43	
27	..	„ two „ „	42	
28	Cr_2Cl_6.	1·186	..	55001 C. C.
29	$Cr K2SO_4,12H_2O$.	8·727	..	2751 C. C.
30	Al_2Cl_6.	1·	..	56251 C. C.
31	$AlNH_4$, $2SO_4,12H_2O$.	3·384	..	31260 C. C.

The observations recorded in these experiments can only be considered exact from a relative point of view, as there were too many contending influences to warrant the figures being taken as individual observations. They, however, conclusively prove the following points: The relative position that the molecules, ferric, chromic, and aluminic

oxides hold as regards dissociation; also, the laws that govern their dissociation in the presence of other salts. Thus, the alums of the ferric oxide, which have been chosen to determine this point, are seen to obey the chemical laws of affinity. As regards the disturbing molecule introduced, its power of substitution determines the lowering of the thermanalytic point; also, the basylous power of this atom determines the amount of decomposition. Where the trioxides alone replace the hydrogen in the acid, the molecules are held together with a force in ratio to the relative affinities; but when a second molecule comes into play, a power of determining or lowering the thermanalytic point is found in the disturbing basylous element introduced. Thus, we find in the alkali group, potash acts more forcibly than ammonia; in fact, they act in this respect according to their power of substitution.

As before stated, the ferric salts have been experimented upon by M. Debray.* That experimenter says—"Je ne suppose pas que le chlorure de fer se dédouble en acide chlorhydrique et en chlorure basique, parce que l'existence de ces composés basique soluble, en tant que composés definis, me parait peu conciliable avec le fait de leur decomposition par le filter dans l'appareil dialyseur, ou par le sel marin qui en precipite de l'oxyde de fer pur. Il me parait plus naturel de considérer ces composés comme des dissolution de l'oxyde colloidal de fer dans l'acide chlorhydrique ou tout au moins dans le sesquichlorure de fer ordinaire."

Now, although M. Debray's views are in the main correct, we cannot conceive that the *action of the dialyzer* can have anything to say to the actual condition of the solution before dialysis. Immediately that we bring a *septum* into play, we introduce another decomposing influence to bear, and entirely modify the balance of the forces at work. I hope shortly to be able to demonstrate—that not only the oxides of the group we have been considering, are capable of existing in either the colloidal or crystalloidal condition—the modifying agent appearing to be in some instances the combined water. There can be little doubt that at elevated temperatures we get a partition of the acid, so arranged as to give an acid salt and a basic salt; and that the amount of basicity is dependent not upon temperature, which only determines a constant decomposition for each degree, but upon a relative volume of water, and when we come to extraordinary pressure, relative volatility of the basylous molecules in the presence of steam. M. Debray again says, "Le chlorure de fer se dédouble donc à une temperature de 70 degrees en acide chlorohydrique et en sesquioxide de fer soluble dans l'eau," &c. All through his paper he speaks of this thermanalytic point, as I will call it, as a constant quantity for the same salt, under all conditions. Now this involves a principle, and I

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* Note sur la décomposition des sels de sesquioxide de fer, par M. Debray.—Comptes Rendus; et Journal de Pharm. et de Chim., Septembre, 1869.

have proved this point, at a given pressure, is entirely dependent as regards this group (and therefore as regards M. Debray's experiments with ferric oxide) upon the relative volume of water.

So sensitive is the potassio-ferric alum, that a fine amethyst coloured crystal, obtained by crystallizing it at a low temperature, when placed upon the palm of the hand, first becomes white, and after a short time yellow. This salt is, of course, the most sensitive of all the group mentioned in this paper.

It may be well to point out that these experiments can only determine the laws of dissociation, practically, to a limited extent. We must build upon them, and conceive in our mind's eye the enormous results that are attainable with the aid of unlimited time and pressure. We are compelled to bring into play the "Scientific use of the Imagination," and bridge over the long gap that lies between our mimic results and those consummated in the laboratory of nature, and by this means to mentally extend our experience. The results are here, but the *modus operandi* is absolutely a sealed book.

I propose to reserve the consideration of the element silicon more particularly in connexion with the bases dealt with in this paper.

Addendum A.

On the Transition of Compounds from the Colloid to the Crystalloid Condition.

In Part I. of this report reference has been frequently made to the fact, that ferric, chromic, and aluminic oxides, and their compounds, are capable of taking the colloidal form.

Now, there is a peculiar character of crystallization discerned in minerals, which is always indicative that the constituents had been previously in their colloidal condition, and had afterwards become crystalloidal. In most cases this change proceeds from assimilation of water of crystallization, but not necessarily so. The characteristic which I wish to specify is where the crystals radiate from a centre, and form in the aggregate what may be termed the radial spherical system. It includes many of the forms technically known as nodular, mammellated, botryoidal, and reniformed masses. Such minerals are formed, in most cases, from aqueous solutions, which had evidently been at one period under the dissociating influence of heat. The iron, manganese, and lime minerals, and also the zeolites exhibits these peculiar forms most strikingly; but none more so than that beautiful mineral, wavellite. The mode by which this form of crystallization is produced cannot be more strikingly exhibited than by an organic salt, which I described some years ago, viz., chlorate of quinia. Although this solution is organic, the formation can be more easily observed in such a case than in the minerals, where time and pressure are such

important elements that it is not capable of experimental verification.

If a very strong and boiling solution of chlorate of quinia be allowed to cool, we find that when the solution arrives at a temperature of about 47° C. the salt begins to fall out, but not in a crystalline form. On examination with a magnifying lens it will be seen that it is separating in globules, which, from the natural laws of fluids floating in fluids, take the shape of perfect spheres. These, as they separate, arrange themselves, as seen in fig. 2 *a*, the *fac-simile* of a microphotograph taken by Mr. Woodworth for me. There is generally one large sphere surrounded by a number of small ones, which frequently coalesce, showing that they are simply obeying the ordinary laws of gravity of mass. The colloid spheres, after some time, become crystalline. Thus, starting from the centre, crystals shoot out to the periphery, and produce those elegantly arranged masses, so well shown in wavellite; indeed, the salt chlorate of quinia, when viewed in the vessel in which it is crystallized, bears such a wonderful resemblance to that mineral that this salt might be aptly termed organic wavellite. If we make a section of one of the globes of wavellite, we shall generally find that outside of the general mass is a layer of crystals, which are evidently a distinct supplementary formation. This would seem to be a further formation of the mineral after it had ceased to be deposited in the colloid spheres, or perhaps the alteration in character of the mineral, from a change in the temperature at which the mineral was no longer deposited in its colloidal condition. Two conditions of deposition are likewise observed in the organic salt. This outside layer generally forms but a small proportion to the mass of the sphere in the mineral. The conversion of the compounds of the trioxides into the colloidal state, on heating their solutions, is rendered probable by their slowness in crystallization, and from the spherical form of crystallization so frequently observed in the minerals of this group. Many of their salts also exhibit this phenomenon. Thus, if a solution of hydrated ferric chloride is crystallized by slow evaporation, distinct and well-formed crystals of the salt are produced; but if it is evaporated by heat to a strong solution, and to such a point that there is a limited amount of available water, it crystallizes by reabsorption of atmospheric moisture in the spherical form,* from the radii striking out to what must evidently have been the periphery of colloidal separations.

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* $Fe_2\,Cl_6$, 6 H_2O, Mohr.

Addendum B.

Minerals to which reference is made in the Report on Molecular Dissociation by Heat.

Mineral.	1 & 2. Calcite and Arragonite.	3. Hematite.	4. Specular Iron Ore.	5. Ochre (yellow).	6. Brown Iron Ore.	7. Corundum.	8. Diaspore.
Authority.	...	Spiller and Smith.	...	Tichborne.	Dick.	J. L. Smith.	Smith.
Fer. Oxide,	...	94·23 90·94	99·	...	52·83	...	...
Ferrous Oxide, . .	...	...	...	...	...		·98
Chromic Oxide, .	...	...	...	...	...	...	...
Alumina, .	...	·63	...	...	...	93·12	84·02
Manganese Oxide, .	...	·23 ·25	...	...	·81	...	...
Lime, .	56·	·65 ·99	...	...	14·61	1·02	...
Magnesia,	...	...	...	...	5·7	0·91	...
Sulphuric Acid, . .	...	·09 ·24	...	1·47	·28	...	...
Carbonic Acid, .	44·	·78	...	...	18·14	...	...
Phosphoric Acid, .	...	...	...	...	·32	...	...
Chlorine. .							
Silica, . .	...	4·9 6·68	trace.	...	...	·96	·43
Iron Pyrites, .	...	...	...	...	4·75	...	...
Water, .	...	·03	...	...	1·30	2·86	14·81
Organic matter, .							
Remarks, .	*Calcite*, or rhombohedral form, specific gravity 2·72 H. 3. *Arragonite*, or rhombic carbonate, 2·9 to 3·8 H 3·5. Arragonite seems to be formed at a higher temperature than calcite, and is more prone to take the colloidal form (globular or radial crystallization).	...	...	The remainder of this mineral nearly consisted of hydrated ferric oxide, and a portion of clay.	The average of twenty-five analyses of brown iron ore give ·032 per cent. of sulphur, exclusive of pyrites. These ores frequently take the globular form.	The water in sapphire, ruby, oriental topaz, &c., averages 2 per cent.; emery, 4 per cent.	Associated with the varieties of corundum.

DESCRIPTION OF PLATE.

FIG. 1, . . . *α.*—Colloid chlorate of quinia deposited from a solution at a temperature of about 47° C. from a microphotograph taken by Mr. Woodworth.

β.—Crystallized chlorate of quinia, in beaker.

„ 2, . . . *α.*—Microscopic appearance of wavellite.

β.—Hemispherical radiated masses of wavellite.

„ 3, . . . *α* and *β.*—Radiated form and appearance of ferric chloride.

„ 4, . . . *α.*—Radial form of natrolite. *β.*—Ditto colloidal terpin.

XXIX.—ANOMALOUS FORM OF COROLLA IN ERICA TETRALIX. By GEORGE SIGERSON, M. D., Ch. M., F. L. S. (With Plate XVII., Science.)

[Read 12th June, 1871.]

THE plant which produced the peculiar corollas about to be described was found growing on the dry top of a bog bank, with some other heath-worts. My attention was at once attracted to it from the apparent presence of polypetalous corollas, through the separations of which the darker anthers were visible. (Fig. 1, Pl. XVII.).

On examining the recent specimens more closely and microscopically, it was clear that the first appearance was somewhat deceptive. There was no regular polypetalous arrangement, but the actual modification of the flower was very curious.

Normally, the corolla of *Erica tetralix* is undivided, or monopetalous. The corollas of the plant in question were divided once, or, in some flowers, oftener. Thus, the examination of one flower showed the corolla divided halfway down to the base; in another it was split to the base. These were instances of least division. In several flowers I found two slits in the corolla, separating it into two pieces. These pieces were often of different sizes. In several flowers, also, three slits existed in each corolla, by which consequently it was divided into three pieces, more or less regularly. (Fig. 1, *a*, *b*, *c*, *d*, *e*).

Normally, the stamens are free from the corolla in the Heath Order. But in this plant there was, in several flowers, a very marked divergence from that rule. Thus, in several instances, part of the divided corolla itself bore an anther or anthers (occasionally imperfect), presenting an appearance somewhat similar to what is seen in the inner metamorphic petals of a double poppy. In other cases, a stamen arose from a divided piece of the corolla; and in a few cases a barren filament alone made its appearance. Here, then, these stamens, instead of being free, as usual in the order Ericaceæ, were epipetalous. Some free stamens (in numerical complement) were also present; in one flower (*a*) a double stamen counts as two.

The divergences exhibited by this plant in the arrangement of its corollas and stamens are not lawless and unaccountable freaks, but may

rather be considered as indications of an attempt to draw its Order nearer to its relatives amongst other families. Thus, the position of the Heath Order among the Corollifloræ seems somewhat anomalous. This sub-class contains dichlamydeous plants, in which the stamens are mostly inserted on the corolla, or epipetalous. The heath-worts are an exception, seeing that they have their stamens free. The case of this plant is, then, that, being an exception to an exception, it harmonizes the Ericaceæ with other families of its sub-class. Both in Primulaceæ and Plantaginaceæ occur polypetalous corollas, with epipetalous stamens. Thus, the division of the corolla in the present plant not only brings it into some resemblance with Calluna and with Leiophyllum (genera of heath-worts in which the corolla is deeply divided), but also it assists, with the epipetalous stamens, to bring the heath-worts themselves into harmonious relationship with the other Orders of the sub-class Corollifloræ.

XXX.—Additions to the Flora of the Tenth Botanical District, Ireland. By G. Sigerson, M.D. (With Plate XVII., Science).

[Read June 12, 1871.]

At the suggestion of Professor Babington, in 1859, Ireland has been divided into twelve botanical districts. The counties of Tyrone, Fermanagh, Monaghan, Cavan, and Armagh, taken together, constitute the tenth botanical district. It is bounded on the north-west by Donegal, the eleventh district, and on the north-east by the twelfth district, formed of the counties of Londonderry, Antrim, and Down.

The additional plants which I have found for the Flora of the tenth district were all met with in its north-western angle, in the latter part of the summer of 1869. This corner of Tyrone, bounded on the north and west by the twelfth and eleventh districts, is a markedly undulating country. The prevailing rocks are limestone and slate. In the particular district which I examined the highest mountain, Owenreagh, is 1360 feet above sea level, and the lowest ground is the floe bog of Leckpatrick, which varies from forty to sixteen feet above sea level, according to the calculations of the Ordnance Survey. The river Foyle, running northwards from Strabane to Derry, passes through a wide valley, which admits the cold north winds without check; but from the margin of the valley to Owenreagh there are many hills, hollows, and mountain glens, well sheltered, and perceptibly warmer. Nevertheless, cereals are reaped in the fertile valley of the Foyle before similar crops have completely ripened in the Antrim portion of the adjoining twelfth district.

In the subjoined list I have mentioned a few plants which have been already recorded from this district of five counties, because they have not been given for the county Tyrone, and because they are

among the scarce or less common plants of this particular locality. Those which—taking the excellent "Cybele Hibernica" for guide—have not been hitherto recorded from this great district, I have marked with an asterisk, and shall distinguish as I read.

DICOTYLEDONES.

ORDER I. RANUNCULACEÆ.

* Ranunculus hederaceus (Linn.). *Lesser Ivy-leaved Crowfoot.*

Wet ditch at Ballyskeagh, 260 feet. This plant did not come under my notice in any other part of the locality. In the adjoining eleventh district I have observed it growing rather abundantly in wet road ditches, on the way from Derry city to the Grianan of Aileach.

R. repens. *Creeping Crowfoot.*

An impoverished specimen of this common plant, found 800 feet high on Knockavoe, presented a double corolla of ten petals.

ORDER II. NYMPHEACEÆ.

Both the white and the yellow water lilies are recorded from this district; but I have not seen them in this locality. They are absent from Moorlough, a mountain lake, 580 feet above the sea-level; though they have been found in Lough Neagh, at the eastern extremity of Tyrone, and abound in the lakelets visible from the road from Ballyshannon to Donegal town, in the adjoining western district. Both plants may exist in the locality, but they cannot be plentifully diffused.

ORDER III. PAPAVERACEÆ.

* Meconopsis Cambrica. *Welsh Poppy.*

On Ballyskeagh hill, near the road. This rare plant is now recorded for nine out of the twelve districts.

ORDER IV. FUMARIACEÆ.

Fumaria capreolata (Linn.). *Ramping Fumitory.*

(Rather frequent).

ORDER V. CRUCIFERÆ.

* Cochlearia Anglica (Linn.). *English Scurvy-grass.*

On the bank of the Foyle, at Clogheor. This is about nine miles south of Derry, up the river, which is tidal for a few miles farther. Dr. Moore mentions that he found this plant at the mouth of the River Roe, and of the Foyle, in Derry, but was not quite sure of the species.* The discovery of it, in the tenth district, on the bank of the same river, tends to confirm the accuracy of his observations.

* *Cyb. Hib.* Recorded, *Ordnance Survey*, vol. i., p. 9.

Order X. Polygalaceæ.

Polygala vulgaris (Linn.). *Milkwort.*

Not infrequent at Tillyard, Knockavoe: some specimens had leaves $\frac{7}{8}$th inch long, and narrow; some had white flowers, though growing in the same place as those bearing blue flowers.

* Polygala depressa (Wend).

Heathy moor, Tillyard, Knockavoe, 800 feet. This is only the third Irish district in which this species has been found; but I think, with the authors of "Cybele Hibernica," that it is "probably frequent in boggy and heathy ground throughout the country." At least, I believe it is not absent from all the other districts.

Order XVI. Geraniaceæ.

* Geranium pusillum (Linn.).

Bank by an old quarry, near Upper Artigarvan; fence, Holyhill.

Order XXI. Leguminosæ.

* Anthyllis vulneraria (Linn.). *Lady's Fingers.*

Bank at Cloghcor, and elsewhere.

* Trifolium procumbens (Linn.). *Hop Trefoil.*

Gravelly and dry banks.

Order XXII. Rosaceæ.

* Prunus insititia (Linn.). *Bullace.*

Scarce. In a hedge, near Upper Artigarvan.

* Prunus avium (Linn.). *Tree Cherry.*

Wooded river bank, Lower Holyhill. Scarce.

Alchemilla vulgaris. *Lady's Mantle.*

Brookside, Liscurry. Scarce.

* Rubus idæus (Linn.). *Raspberry.*

Locally abundant on banks and braes about Holyhill, and in a few hedgerows.

* Pyrus malus (Linn.). *Crab-tree.*

These trees are locally called scribe trees, and the crab apples are termed scribes. One old tree stands near Glenmornan chapel, and indeed served as a chapel in former times. Another old tree grows in a holm beside the Tod Knows (or Fox Knolls), Artigarvan; it is respected as a fairy tree. These trees are certainly indigenous.

* Pyrus aucuparia (Gaert). *Mountain Ash.*

Upper part of Glenmornan, &c.

ORDER XXIII. LYTHRACEÆ.

Lythrum salicaria (Linn.). *Purple Loose-strife.*

Foyle bank, at mouth of Glenmornan river. Scarce in the locality, though common on the opposite bank of the Foyle (eleventh district).

ORDER XXIV. ONAGRACEÆ.

Circæa alpina. *Alpine Enchanter's Nightshade.*

Bank of the Glenmornan river, at Lower Holyhill, about three miles north of the glen of Strabane, in which Admiral Jones discovered it. It has not been recorded from the other counties of the district.

ORDER XXVIII. CRASSULACEÆ.

* Cotyledon umbilicus (Linn.). *Wall Pennywort.*

Walls of high road, near Strabane glen; walls of the "sweat-house," Ballylaw, Liscurry.

ORDER XXXVI. VALERIANACEÆ.

Valeriana officinalis. *Wild Valerian.*

River bank and ditches, Lower Holyhill. Not frequent.

ORDER XXXVIII. COMPOSITÆ.

Bidens cernua (Linn.). *Nodding Bur-marygold.*

Water ditches beside Leckpatrick floe bog. Not observed elsewhere.

Achillea ptarmica (Linn.). *Sneezewort.*

Banks. Rather infrequent.

* Chrysanthemum segetum.

Var β pusillum. *Least Corn Marygold (New Variety).**

The common corn marygold is a frequent plant in cultivated fields in this district, where it is popularly called the "gilgowan." Usually over a foot high, strong and straggling, it has broad ovate-stalked lower leaves, stem clasping, deeply dentate upper leaves, and large conspicuous yellow flowers. In a fallow grass field,† at Liscurry, lying between the white fort and the Donemana road, I discovered a very well marked variety, which I propose to name as above.

This variety has a very slender erect stem, unbranched, two or three inches in height; leaves sessile, linear, entire, under half an inch in length; capitulum small, having only about half-a-dozen florets.

It had become established all over the field, and showed its flower heads on a level with the grass, by which its fragile stems, slighter than

* See Plate XVII., fig. 2.

† And (since) in other fields.

young flax, which it somewhat resembles, were altogether concealed. At a short distance the common corn marygold was growing, at full length, in the corn and potato fields.

Carduus palustris (Linn.). *Marsh Thistle.*

Wet ground, beside Leckpatrick floe bog. The flower heads, instead of being purple, were of a whitish colour.

Centaurea cyanus (Linn.). *Corn Blue-bottle.*

Found occasionally in cropped fields.

* Leontodon taraxacum (Linn.) *Dandelion. Var.* γ.L.palustre. (Smyth).

Occasionally in moist places.

Order XL. Ericaceæ.

Vaccinium oxycoccos (Linn.). *Cranberry.*

The floe bog of Leckpatrick, beside the River Foyle. Not common on the mountain moors.

Order XLI. Aquifoleaceæ.

* Ilex aquifolium (Linn.). *Holly.*

On the round hill known as Holyhill, but sometimes called Hollyhill, and elsewhere in the vicinity.

Order XLII. Oleaceæ.

* Ligustrum vulgare (Linn.). *Privet.*

Banks of Glenmornan river, above Artigarvan. Not planted where found growing, but possibly an escape from cultivation.

Order XLIII. Gentianaceæ.

* Erythræa centaurium (Linn.). *Centaury.*

Hilly pasture field, Pollockstown, Cloghcor.

Menyanthes trifoliata (Linn.). *Bog-bean.*

Upland pools. Rather infrequent.

Order XLIV. Convolvulaceæ.

* Convolvulus sepium (Linn.). *Great Bindweed.*

Among reeds on Foyle bank, at mouth of canal; hedge near Strabane.

Order XLVIII. Scrophulariaceæ.

Scrophularia nodosa (Linn.). *Figwort.*

Roadside bank, Ballyskeagh. Mourne banks, Strabane. Rather scarce.

Euphrasia odontites (Linn.). ***Red Bartsia.***

Roadsides, Ballyskeagh, and Liscurry. Not very common.

Digitalis purpurea (Linn.). *Foxglove.*

* Var. β. candida.

This plant is common in suitable localities. In a grove, by the river, above Artigarvan, I have observed for several consecutive years that one or two specimens produced purely white flowers. This variety is here recorded because the specific name (purpurea) refers to the colour.

* Mimulus luteus (Willd). *American Monkey Plant.*

Two or three specimens of this plant were found growing on a piece of waste ground between the Glenmornan river and canal, near their junction with the Foyle. Originally, of course, it escaped from some of the gardens up the stream, but the plants seemed to thrive well. This is the third district in which it has been found wild, Mr. Carrol having discovered it in two places in the county Cork, and Mr. More on a rock at the salmon-weir of Ballyshannon.

ORDER XLIX. LABIATÆ.

Mentha aquatica (Linn.). ***Water Mint.***

Banks of the Glenmornan river, near the Foyle. Locally abundant.

Mentha sativa (Linn.). ***Marsh Mint.***

Same locality. This plant is stated to be "very rare in Ulster."

* Mentha arvensis (Linn.).

In fields where flax had been growing, at Artigarvan and Liscurry.

ORDER LI. LENTIBULARIACEÆ.

Utricularia minor (Linn.). ***Lesser Bladderwort.***

Ditches and pools, Leckpatrick floe bog.

ORDER LII. PRIMULACEÆ.

—Primula veris (Linn.). *Cowslip.*

I name this plant to note its absence from this portion of the district. In Armagh, the eastern county of this district, Mr. A. G. More found the cowslip "frequent about Loughgall, where the primrose is exceedingly rare." In the north-west part of Tyrone the contrary happens. Primroses are plentiful by every hedgerow, but both oxlip and cowslip seem unknown.

ORDER LIV. PLANTAGINACEÆ.

Plantago lanceolata (Linn.). ***Ribwort Plantain.***

* *Var.* β. major. Leaves stalked, over a foot in length. Banks between canal and Foyle.

Littorella lacustris (Linn.). *Shoreweed.*

Local. On a muddy shore at Moorlough, 580 feet.

ORDER LXIII. AMENTIFERÆ.

Quercus robur (Linn.). *Oak.*

Q. Robur pedunculata. *Pedunculate Oak.* Frequent.

* *Var. β.* Q. R. sessiliflora. This variety, described as rare and local in Ireland, observed by Dr. Moore in a few localities in Antrim, occurs with the other in the neighbourhood of Holyhill.

ORDER LXXIII. JUNCACEÆ.

* Juncus squarrosus (Linn.). *Heath Rush.*

On Leck bog 16 feet, and at Tillyard, about 800 feet, on the side of Knockavoe.

ORDER LXXIV. ALISMACEÆ.

Alisma plantago (Linn.). *Great Water Plantain.*

Water trenches, Leckpatrick. Local; not frequent.

* Triglochin palustre (Linn.). *Marsh Arrow-grass.*

Ballyskeagh bog.

ORDER LXXV. TYPHACEÆ.

Typha latifolia (Linn.). *Great Reed-mace.*

Cloghcor. Becoming very scarce.

Sparganium ramosum (Huds.). *Branched Bur-reed.*

Water ditches, Leckpatrick brickfields.

ORDER LXXVIII. POTAMOGETONACEÆ.

Potamotegon perfoliatus (Linn.). *Perfoliate Pond-weed.*

Strabane Canal. Ballymagorry.

* Potamotegon pusillus (Linn.). *Small Pond-weed.*

Same locality.

ORDER LXXXI. GRAMINEÆ.

Arundo phragmites (Linn.). *Common Reed.*

Foyle bank, near canal. This plant is sometimes used for thatch.

* Lolium temulentum (Linn.). *Darnel.*

Cultivated fields. Occasionally found.

This list, from which I have excluded all specimens about which I felt doubtful, furnishes some thirty additional plants, not previously recorded, to the Flora of our Tenth Botanical District.

XXXI.—ON THE RESPIRATION OF COMPRESSED AIR. By THOMAS HAYDEN, F. C. P. &c.

[Read 26th June, 1871.]

FOR normal respiration, so far as it relates to the atmosphere, three conditions are necessary—an adequate supply of dilute oxygen, comparative freedom from gaseous impurity, and a state of equilibrium between the gases contained in the blood and tissues of the body, and the surrounding air.

I do not propose to discuss the two former conditions in this Paper; but in regard to the latter, derangement of equilibrium may take place, either by rapid reduction, or by rapid augmentation of barometric pressure.

As a consequence of rapid diminution in the density of the air breathed, the group of phenomena constituting the *Mal de Montagnes* is exhibited. These are—Nausea, headache and vertigo, great difficulty of breathing, palpitation and panting, accelerated pulse, *tinnitus aurium*, a feeling of lassitude and dejection, somnolence, bleeding from the gums and lips, and suffusion of the conjunctivæ; as determined by Humboldt and his companions, and by a host of subsequent observers, at great altitudes.

Lepileur declares that these symptoms entirely disappear after a certain time under the same barometric pressure, so that inconvenience is no longer experienced, the organism having accommodated itself to the altered circumstances in which it is placed. In other words, the barometric equilibrium between the gases permeating the body and the surrounding atmosphere, is re-established.

The inhabitants of high regions find themselves normally under these conditions, and experience no particular inconvenience therefrom. Thus, in Deba, in Thibet, the residence of a Lama, which is nearly 5000 mètres above the level of the sea, and about the same height as the summit of Mont Blanc, atmospheric pressure is reduced to about one-half, yet the inhabitants suffer no special inconvenience.

Longet considers that the too sudden diminution of atmospheric pressure must profoundly modify oxygenation, and so produce the above-mentioned consequences—a certain time being necessary for the readjustment of the balance between the gases of the blood and those external to the body.

It is remarkable that æronauts, who ascend much more rapidly into the higher regions of the atmosphere, by no means experience in the same degree the symptoms of the *Mal de Montagnes*. This difference is probably due to the state of quiescence of body in which they are placed, comparatively with those who, by great muscular efforts, make the ascent of high mountains.

The sequence of the phenomena constituting the *Mal de Montagnes* may be thus explained :—

In ascending high mountains, the great and rapid disintegration of muscle involved in the efforts demanded, renders increased rate of respiration necessary, partly to supply the additional oxygen required for the oxidation of the used-up tissues, and in part to cast off by the lungs the gaseous products of augmented chemical change. Again, the percentage of oxygen by volume in the air decreasing as its density, the number of inspiratory acts must be proportionately increased to supply the amount of oxygen required.

Hence accelerated respiration; but by a fixed physiological law the rate of circulation is definitely proportioned to that of breathing, and hence palpitation, quick pulse, and *tinnitus aurium*.

The head symptoms—headach, vertigo, and somnolence—are in a measure due to the last-mentioned cause; but in some degree likewise to the circulation in the sensorium, in the first instance, of imperfectly decarbonized blood.

Nausea I regard as a reflex symptom, due to deranged intracranial circulation.

The feeling of lassitude and depression of spirits, drowsiness, and superficial hæmorrhages, are the direct result of deranged gaseous equilibrium; the surface pressure being insufficient to counterbalance that of the elastic fluids within the body. Blood is consequently forced to the surface on the same principle as by the operation of a cupping-glass, but in a minor degree.

The effect of damp weather upon the spirits and bodily vigour is proverbial; it is in part due to the gloomy aspect presented by nature enshrouded in mist; but mainly to the accompanying reduction in barometric pressure.

How this operates upon the body so as to depress vital energy, is not well understood. My impression is that the effect in question is produced by lowered vascular pressure upon the nerve centres, consequent upon repletion of the superficial vessels.

The unpleasant symptoms, mentioned as experienced by a person passing quickly, and with great muscular effort, into the higher regions of the atmosphere, are of very brief duration, and attended with no bad consequences, if the lungs and vascular system be healthy, and capable of bearing the strain involved in the sudden transition.

On descending into the more dense strata of the air the traveller will experience a new series of phenomena, or rather the former series modified. The surplus pressure is now *ab extra*, and the symptoms consequent upon exposure to, and respiration of, compressed air, but in the relative sense only, are exhibited.

Of the effects produced by the respiration of air absolutely compressed, and of greater density than that represented by the standard barometric pressure of thirty inches of mercury, comparatively little has been made known. This is mainly due to the absence in nature

of the conditions requisite for the experiment, and the difficulty of artificially constructing a suitable apparatus for the purpose.

Tabarié in 1838 demonstrated by a series of experiments that great and progressive condensation of the air surrounding the body, and breathed by it, has the effect of slowing the pulse and the respiration, and of lowering the temperature of the body, both subjective and objective.

In 1850 Pravaz showed that under a pressure increased by half an atmosphere, the pulse sensibly falls, sometimes by two-fifths, respiration becomes slower but more ample, muscular contraction acquires more energy, and there is increased exhalation of carbonic acid up to a pressure of ten to twelve centimetres, above which limit it is diminished. He found, moreover, that on leaving the condensed air-bath, the exhalation of carbonic acid was again increased, and attained its maximum only a certain time subsequently.

Longet declares that "many of these results are not intelligible, and need confirmation."

In the building of the bridge of Kehl a few years ago, Bucquoy made observations on himself and others, as to the effects of breathing compressed air. He noted restlessness and a feeling of oppression, irregularity of breathing, consisting in abbreviation of the inspiratory, and prolongation of the expiratory act, quickening of the pulse and palpitation, pain in the ears as if from the impaction of a foreign body, and so severe as to make the subject cry, impairment of hearing, and voice of a nasal quality and requiring an effort; the movements of the limbs were easier than natural, and under a pressure of two and a half atmospheres it was impossible to whistle, and there was copious perspiration.

The pain in the ears alternately went and returned till it finally ceased, and simultaneously the breathing became tranquil.

On returning into the open air he experienced a feeling of cold, the breath formed a dense cloud, there was a return of palpitation and irregularity of breathing, and likewise of pain in the ears, all of which lasted only a few minutes.

The air consisted of	Oxygen, ...	19·23,
	Nitrogen, ...	80·77,

and contained a large excess of carbonic acid, amounting to more than two parts in a hundred.

The labourers lost flesh and appetite, and experienced muscular pains, and symptoms of congestion of the brain and lungs. Blood drawn from the veins was in some instances bright red, especially after long exposure to compressed air.

By means of the sphygmograph and the ophthalmoscope Dr. Burdon-Sanderson has ascertained that the effect of inhaling compressed air is to diminish the volume of blood in the veins and auricles, and to increase that in the arteries and ventricles. Hence, he infers, it is useful in the treatment of pulmonary emphysema, chronic bronchitis,

and allied affections, in which the right heart and the veins are congested, and the left heart and the arteries comparatively empty.

With reference to the curative application of high atmospheric pressure alluded to in the last sentence I will make a few observations further on.

In the building of the great bridge now in course of construction across the Mississippi at St. Louis, observations of the utmost value to science have been made upon this subject.

Through the courtesy and kindness of my friend Dr. Thomas O'Reilly, an eminent medical practitioner at St. Louis, I have been favoured with a copy of the chief engineer's Report, from which I shall borrow a few extracts bearing upon the subject of this Paper. The Report itself I shall have much pleasure in presenting to the Academy, as from it alone an adequate conception of the vastness of the work engaged in, and of the great engineering skill developed in its execution, can be formed.

In regard to the subject under discussion it may be confidently stated that never hitherto has the experiment of subjecting the human body to the operation of compressed air by immersion and respiration, been performed on so large a scale, and in so extreme a degree.

The chief engineer, Colonel Eads, says: "A column of water one hundred and ten feet six inches in height would be equal to a pressure of 47·96 pounds per square inch, assuming the weight of the water to be 62·5 pounds per cubic foot. The greatest pressure marked by the gauges was fifty-two pounds, and it is not probable that the pressure in the air-chamber ever exceeded fifty, or fifty-one pounds."

Effects of Compressed Air on the Men.

"The first symptom manifesting itself, caused by the pressure of the air, is painfulness in one or both ears. The Eustachian tubes extending from the back of the mouth to the bony cavities over which the drums of the ears are distended, are so minute as not to allow the compressed air to pass rapidly through them to these cavities, and when the pressure is increased rapidly, the external pressure on the drums causes pain. These tubes constitute a provision of nature to relieve the ears of such barometric changes as occur in the atmosphere in which we live. The act of swallowing facilitates the passage of the air through them, and thus equalizes the pressure on both sides of the drums, and prevents the pain. The pressure may be admitted into the air-lock so rapidly that this natural remedy will not in all cases relieve it. By closing the nostrils between the thumb and fingers, shutting the lips tightly, and inflating the cheeks, the Eustachian tubes are opened, and the pressure on the inner and outer surfaces of the tympanum is equalized, and the pain prevented.

"This method must be used and repeated, from time to time, as the pressure is let on, if it be increased rapidly. No inconvenience is felt by the reaction when the pressure is let off, as the compressed air

within the drums has a tendency to open the tubes, and thus facilitates its escape through them; whereas increasing the pressure has the effect of collapsing them, and therefore it makes it more difficult to admit the compressed air within the cavities of the ears. It frequently occurs, however, from some abnormal condition of these tubes, as when influenced by a cold in the head, that neither of these remedies will relieve the pain.

"To continue the admission of compressed air into the lock, under these circumstances, would intensify the suffering, and possibly rupture the tympanum: therefore the lock tenders were particularly instructed to shut off the compressed air at the moment any one in the lock experienced pain about the ears; and then, if it could not be relieved by the above means, the lock was opened, and the person was not permitted to go through into the air-chamber. Sometimes fifteen minutes were occupied in passing persons through the first time, after which they usually had no further trouble from this cause.

"The fact that the depth penetrated by the air-chamber was considerably greater than that hitherto reached in any similar work, left me without any benefit from the experience of others in either guarding against any injurious effects of this great pressure upon the workmen and engineers subjected to it, or of availing myself of any known specific for relieving those affected by it. When the depth of sixty feet had been attained, some few of the workmen were affected by a muscular paralysis of the lower limbs.

"This was rarely accompanied with pain, and usually passed off in the course of a day or two. As the penetration of the pier progressed, the paralysis became more difficult to subdue. In some cases the arms were involved, and in a few cases the sphincter muscles and bowels. The patients also suffered much pain in the joints when the symptoms were severe. An average of at least nine out of ten of those affected suffered no pain whatever, but soon recovered, and generally returned to the work.

"The duration of the watches in the air-chamber was gradually shortened from four hours to three, and then to two, and finally to one hour.

"The use of galvanic bands or armour seemed, in the opinion of the superintendent of construction, the foreman of the chamber, and the men, to give remarkable immunity from the attacks. They were all ultimately provided with them. These bands were made of alternate scales of zinc and silver, and were worn around the wrists, arms, ankles, and waist, and also under the soles of the feet. Sufficient moisture and acidity were supplied by the perspiration to establish galvanic action in the armour, and as the opinion amongst those most accustomed to the chamber was almost unanimous in favour of this remedy, I am very much inclined to believe it valuable.

"The total number of men employed in the air chamber of this pier was 352. Of this number about thirty were seriously affected. Notwithstanding the care and skill with which those most severely

attacked were treated, twelve of the cases proved fatal. Each of these, without exception I believe, was made the subject of careful inquest by the coroner, aided by an autopsy conducted usually by some of our most skilful surgeons and physicians. Whilst the exciting cause in all these cases was doubtless the exposure of the system to the pressure of the condensed air of the chamber, the habits and condition of several of those who died were, at the time they went to work, such as would have excluded them from it if subjected to the examination of Dr. Jaminet; and the verdict in about one-half of the cases gave a totally different cause for the death of the patient. Nearly or quite all of these deaths happened to men unaccustomed to the work; several of them to men who had worked but one watch of two hours. In contrast to this is the fact that quite a large number of the men (certainly one-half of those constantly employed) commenced with the work at its inception, and remained throughout its continuance entirely without injury or inconvenience.

"Much diversity of opinion was expressed by the medical gentlemen who investigated the symptoms, and held autopsies of the deceased. Some of these gentlemen maintained that a slower transition from the abnormal to natural pressure would have been less injurious; others claimed, on the contrary, that it was from the too rapid application of pressure in passing from the natural into the compressed air. The fact that the air-lock tenders were in no case affected, although subjected many times during a watch of two hours in the air-lock to rapidly alternating conditions of the atmosphere, at one moment in its normal state in the lock, and five minutes later exerting a pressure of 50 lbs. per square inch upon every part of the body, would seem to prove both of these theories unsound, and lead us to believe that in the length of time to which the human system is subjected to this extraordinary pressure exists the real source of danger, and not from any rapid alternations of pressure to which it is exposed. After the caisson reached the rock, I have frequently, when passing through the air-lock, admitted the compressed air into it so quickly that none but those well accustomed to it could relieve the pressure upon their ears, and yet I felt no ill effects whatever from this rapidly increasing pressure; and in going out I have let the pressure off so fast that the temperature in the lock has fallen thirty-two degrees, Fahrenheit, in consequence. These transitions occupied but three or four minutes.

"The fact that the air-chamber was briefly visited by thousands of persons, including many delicate ladies, even after it had reached the bed-rock, some remaining as long as an hour in it, without any of them experiencing the slightest ill effects from the pressure; and the fact that no cases of any importance whatever occurred among the workmen after the watches were reduced to one hour, satisfies me that this is the true cause of the paralysis, and that by lessening still more the duration of the watches, a depth considerably greater can be reached without injury to the workmen. Too long a continuance in the air-chamber was almost invariably followed by symptoms of exhaustion and paralysis.

"Dr. Jaminet on one occasion remained in two and three quarter hours, when the depth was over ninety feet, and was dangerously attacked soon after reaching home.

"Symptoms of paralysis rarely occurred in the shaft, but generally after the stairs were ascended, and never in the air-lock or air-chamber."

The importance to the present subject of the preceding extracts, both in regard to the facts stated, and the inferences drawn from them, is my apology for their great length. The amount of information in physiology, and the critical acumen which the writer has exhibited in the observations just quoted, are eminently creditable to him.

Before I proceed to discuss the opinions enunciated by him, and make some general remarks on the subject under consideration, I wish to supplement what has been taken from the chief engineer's Report, by some very pertinent observations contained in Dr. O'Reilly's letter. He says:—"Aside from its importance in showing the obstacles which modern engineering science can overcome, by constructing the piers of a bridge of such magnitude as to support spans of five hundred and fifteen feet, sinking them as they build from above downwards, through water and sand one hundred and fifteen feet deep, to the rock-foundation, with a strong current equal to six miles per hour, and the atmospheric pressure in the caisson, or chamber under the pier, in which the workmen shovel the sand to the pumps, by which it is gradually sunk to the bottom, is equal to four atmospheres, or say sixty pounds to the square inch; it is important to the physiologist, as this unusual pressure in the human body has developed a train of symptoms pretty accurately described in the engineer's Report.

"I saw many of the men afflicted with the painful feelings described, and their agony was very great; but I found nothing to relieve them, except the subcutaneous injection of morphine, and hypnotic doses of the chloral hydrate. I do not think that the galvanic armour mentioned by Colonel Eads had the slightest advantage beyond its moral effects as a diversion to the mind. None of those I attended died, and I was not present at any of the *post mortem* examinations."

Unfortunately the Report contains no account of the structural lesions, if any, exhibited by those who died from the effects of exposure to compressed air, and no statement of the per centage of carbonic acid in the air expired under the pressure of four atmospheres. I hope to obtain some additional information on this part of the subject, and if successful in my endeavours I shall have much pleasure in submitting it as a supplement to this Paper at a future meeting of the Academy.

According to Vivenot the inhalation of compressed air reduces the frequency of the pulse on the average about six and a half pulsations in the minute. This effect he attributes to the mechanical pressure of the heavier air on the surface of the body, and consequent reduction

of the calibre of the vessels, and increased obstacle to the propulsive force of the heart.

The vessels were seen to contract on the conjunctivæ, in the retina, and in the ear of the rabbit. In regard to respiration it produces a twofold effect—augmentation of the capacity of the lungs through dilatation of the vesicular structure, and the introduction of a larger quantity of air; the latter effect is in part due to expansion of the air-sacs, but mainly to the condensed character of the air inspired.

From the observations hitherto made it may be concluded that the effects upon the human body of protracted immersion in, and respiration of, compressed air are :—

1. Slowing of the respiration, and derangement of its normal rhythm.
2. Retardation of the pulse.
3. Contraction of the superficial blood vessels.
4. Dilatation of the air-sacs and vesicles of the lungs.
5. Pain in the ears, and loss of hearing.
6. Nasal voice, and inability to whistle.
7. Muscular paralysis.
8. Depression of temperature.
9. Copious perspiration.
10. Diminished exhalation of carbonic acid.

It will be noticed that most of these effects are in direct contrast with those previously mentioned as arising from exposure to, and inhalation of, highly rarified air, and taken collectively they constitute a complex and very difficult problem in physiology. Without undertaking in this Paper to discuss them in a complete manner, I shall notice a few of the more interesting, and offer such remarks thereon as the time and space now at my disposal admit.

Oppression, slow pulse and breathing, and irregularity of the latter, seem due in great measure to repulsion of blood from the surface upon the internal organs by the mechanical pressure of the condensed air, and consequent congestion of the respiratory and circulatory nerve-centres. Hence, irritation of the roots of the pneumogastric nerves, and the usual effects of such, namely, slow and irregular breathing, and inhibition of the heart's action. In regard to the breathing there is, however, another cause in operation which must not be omitted, namely, the alteration in the relative diffusibility of the gases within, and those external to the body, and the consequent modification of Graham's law in a sense unfavourable to respiration. The experiments of Mitchell and Rogers of Philadelphia have made it no longer doubtful that gases held in solution, and separated by porous membranes, are thereby in no degree exempted from the operation of this law.

Pain in the ears and suspension of the faculty of hearing were caused by the pressure of a heavy column of air upon the membranes of the tympana, unsupported by equal counter pressure. After a short

time, as mentioned by all observers, this pain ceases, manifestly owing to the penetration into the cavity of the tympanum, of the condensed air by way of the Eustachian tube. The entrance of air to the middle ear by this devious and compressible passage requires a short time for its accomplishment, but may be instantaneously effected by an act of swallowing, by which the tube is for a moment expanded, or by inflation of the pharynx, as stated and correctly explained by Colonel Eads. The return for a moment of the aural pain on passing into the normal atmosphere was due to a fresh derangement of gaseous equilibrium, but now by a transposition of the inequality.

The nasal character of the voice, and the inability to whistle, would seem mainly due to the necessary modification of elasticity in the condensed air, by which its capacity to propagate sonorous vibrations was altered in a proportionate degree; but impairment of contractile power in the muscles of the palate and lips, by reason of the heavy atmospheric pressure born by them, probably contributed in some degree to this result.

Paralysis of the voluntary muscles was most likely due in greatest part, if not exclusively, to muscular exhaustion; and this opinion would seem borne out by the statement of Colonel Eads, to the effect that it occurred in no instance in which the subject of it had not performed protracted duty in the condensed air-chamber, and that in all cases where death did not actually follow, it was of very brief duration, not exceeding in any case a period of two days. Depression of body-heat would follow impairment of the respiratory function, whilst sensible and copious perspiration would obviously result from the diminished hygrometric capacity of highly condensed air.

The normal exhalation of carbonic acid amounts to about 4·35 per cent of the expired air, and the decrease consequent on the respiration of compressed air might be accounted for, at least in part, by a notable reduction of more than two per cent. in the proportion of oxygen in that air.

It now only remains for me to discuss the dilatation of the pulmonary structure, and to make a few concluding remarks on the therapeutic applications of compressed air.

A state of equilibrium of the ultimate pulmonary structure, admitting of alternate contraction and dilatation, strictly proportioned to the mobility of the chest walls, is not only normal to it, but likewise essential to its functional efficiency. This state is the result of two opposing and usually well balanced forces, one tending to expand, and the other to contract or reduce the volume of the lungs. The former of these forces consists of the active expansion of the chest by the muscles of inspiration, supplemented by the elastic expansion of the air within the lungs under the influence of the normal heat of the body; and the latter, ordinarily of the passive or elastic reaction of the chest walls, aided by that of the lungs. A still further reinforcement of either of these agencies by any cause whatever, would derange the balance of respiration, and constitute a morbid condition. Mani-

festly such a state of the atmospheric air introduced into the lungs as would be competent by its greater weight and expansile capacity, to increase the pressure upon their internal surface, would constitute a cause of this kind, and be exemplified in the breathing of compressed air.

It seems clear, therefore, that the lungs are the organs primarily and most directly affected by the inhalation of compressed air, and that, curatively, any condition of the lungs involving impairment of their capacity for elastic reaction, or permanent expansion of their structure, would be unsuited for the therapeutic application of compressed air. Yet I find Dr. Burdon-Sanderson declaring his opinion that it would be useful in the treatment of pulmonary emphysema, and chronic bronchitis, in which there is morbid and permanent expansion of the lungs owing to impairment or loss of elasticity of their structures, and in which, moreover, the right chambers of the heart and the systemic veins are engorged with blood. I need scarcely say that I cannot subscribe to this opinion. I believe that in such a condition of the lungs and right heart, the respiration of compressed air would greatly aggravate the evil proposed to be remedied. I think it likely, however, that if a suitable appliance were devised, by which compressed air, exceeding a pressure of two and a half atmospheres, or of still greater density, according to the object sought to be attained, could be introduced into the lungs, whilst the body was subjected to ordinary atmospheric pressure, great benefit would arise therefrom in the treatment of atelectasis, or chronic tuberculosis of the lungs, or of pleuritic effusions of long standing with collapse or compression of the lung.

XXXII. — On a New Form of Spectroscope. By G. Johnstone Stoney, M. A., F. R. S.

[Read June 26, 1871.]

1. If θ be the minimum deviation of a ray in a prism, or a battery of prisms, and i its inverse wave-length, *i. e.* the reciprocal of its wave-length, then

$$\delta = \frac{d\theta}{di} \qquad (1)$$

may be taken as a convenient measure of the dispersion.

This will assume a numerical form, if we measure the deviations in tenths of a minute of arc, and the wave-lengths in fractions of a millimetre. The inverse wave-lengths will then be the denominators of these fractions, and δ will be the number of tenths of a minute of arc, over which one unit of this scale of inverse wave-lengths is dispersed.

The value of δ so defined will vary from point to point along the spectrum, having usually between two and three times the value

at the blue end of the spectrum, that it has at the red end. The law of variation will depend partly on the material of the prisms, and partly on their angle.

Hence, to give definiteness to a comparison between different instruments, some region of the spectrum must be selected, at which the comparison shall be made. Accordingly, we shall regard as the dispersion of a prism the value of δ at that point near the middle of the spectrum, where i = 2000, and W (the wave-length in tenth-metres) = 5000.* Defined in this way the dispersion of the battery of three prisms in the great Grubb Spectroscope of the Royal Dublin Society is 12.

But the dispersion of a spectroscope must be carefully distinguished from δ the dispersion of its prisms. For the dispersion of a spectroscope is equal to the dispersion of its prisms multiplied by the power applied to its telescope. The actual dispersion accordingly depends upon the eye-piece used, and is variable; but there is in each spectroscope a certain *standard dispersion*, which is perfectly definite, and to the credit of which the instrument is entitled. This is the dispersion which is obtained when the telescope is armed with the highest power that may, without loss of light, be applied to it.

When a spectroscope is directed towards an object producing bright lines, such as a sodium flame, or nebula, there is a certain intrinsic brightness of each line, which no disposition of our apparatus can enable us to pass, so long as we confine ourselves to vision with one eye. The most the instrument can do is to show us the lines of this maximum brightness, diminished only by the inevitable losses from absorption in passing through the glass, and from reflection and scattering at the polished surfaces.

This maximum brightness will be attained whenever the power of the eye-piece, with which the telescope is armed, is sufficiently low to emit pencils of light, which fill the whole diameter of the pupil of the eye. The highest power which will do this is—

$$\frac{a}{\alpha}$$

Where a is the aperture of the spectroscope (*i.e.* the diameter of the pencil of light passing through the prisms, and the two object lenses), and α the diameter of the pupil of the eye (which may be taken to be five millimetres, or 0·2 of an inch). If a higher power than this standard be applied to the instrument, the lines become fainter; if a lower power be applied, a part of the aperture of the spectroscope is left out of use, and an instrument with smaller prisms would act as well.

When armed with this power, the dispersion of the spectroscope becomes

* At this point of the spectrum one unit on the scale of inverse wave-lengths is equal to 2·5 units on Ångström's scale of direct wave-lengths.

$$\Delta = \frac{a}{a} \cdot \delta \qquad (2)$$

It appears from this expression that, without impairing the brightness of the lines, we may increase the dispersion of a spectroscope in either of two ways. Either by adding to the number of the prisms, which increases δ, or by enlarging their size, which increases a.

It becomes then a matter of practical importance to determine in which of these two ways very powerful spectroscopes can best be made; and the object of this communication is to point out the advantages to be expected from increasing the aperture rather than the number of the prisms. In the first place, there is less loss of light. The loss of light by absorption is the same as when the number of prisms is increased, but there are fewer surfaces at which light is wasted by reflection and scattering. But the great advantage would appear to be in defining power, for in the proposed arrangement much of the optical work will be thrown on the telescope lenses instead of on prisms; and as telescope lenses can in practice be made much more perfect as optical appliances than prisms, a considerable advantage may be expected in this way. From this is to be deducted the consequence of any increased defect which may arise in the manufacture of large rather than small prisms; but making every probable allowance for this, there seems a large outstanding balance of advantage to be reasonably expected from the employment of large prisms.

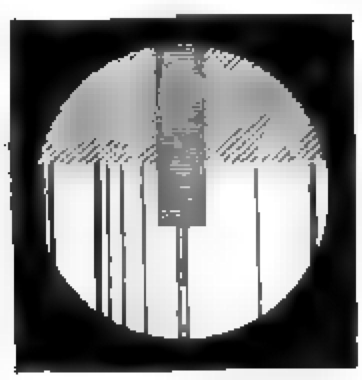
The substance of the foregoing investigation is taken from an inquiry into the geometrical optics of the spectroscope, especially in its application to astronomy, which I wrote out in February, 1866, for the use of a friend. But I had not, until lately, an opportunity of testing the conclusion to which it seemed to lead. It will, however, be fully tested in using a powerful spectroscope, which Mr. Grubb has undertaken to make as part of the apparatus furnished to me by the Academy for investigations into the properties of gases.

In this instrument we propose to employ an object mirror in preference to an object lens, to save expense; and to save expense, bulk, and complexity, the light will be reflected back upon its course, so as to make one object mirror do duty both as collimator and telescope. With these arrangements the light will suffer three reflections from silver films, but on the other hand the instrument will be extremely simple in its mechanical arrangements, very compact, and of great aperture, as compared with its cost.

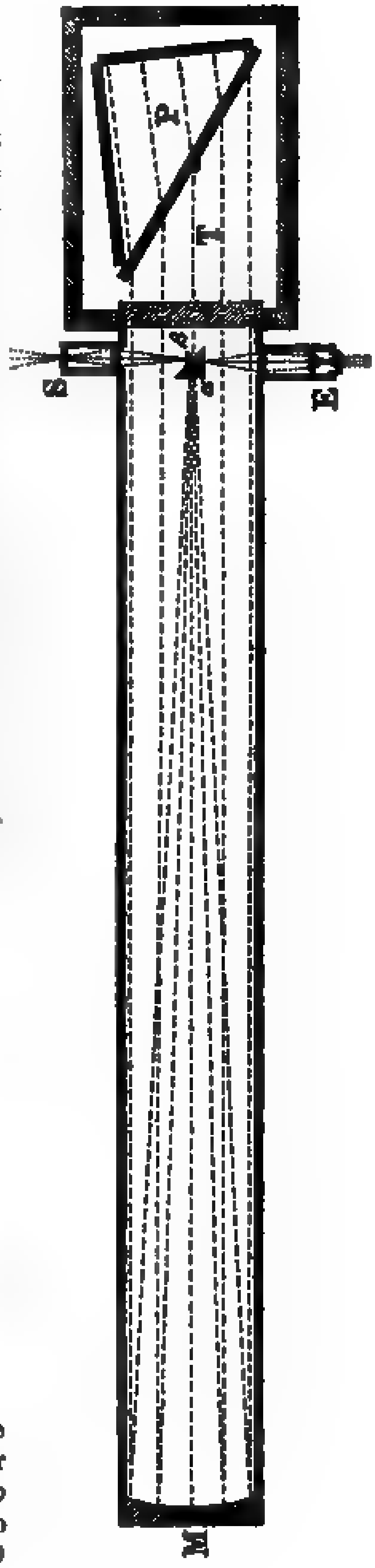
The sketch on the following page of a plan of the apparatus will give an idea of its construction.

S is the chink, of which an optical image is formed within the minute reflecting prism β, which is cemented to the back of the larger reflecting prism α. The light after reflection from β falls in a diverging beam upon the mirror *M*, by which it is transmitted as a parallel beam into the tank *T*, from which it enters the semi-prism *P*. It is then reflected by a silvered mirror, which forms the back of the semi-prism, and returned on its course, so that falling on *M* as a paral-

lel beam, it is by it brought to a focus on α, by which it is reflected into the eye-piece *E*. The image being formed on the back of α, the eye-piece must be a microscope capable of examining an object at that distance. The semi-prism will be filled with bisulphide of carbon, and will be plunged in a tank containing a liquid which shall possess the three following properties: a low dispersive power, a refractive index bordering upon that of the glass window of the semi-prism, and a specific gravity nearly that of bisulphide of carbon. We are at present engaged in ascertaining whether glycerine or a solution of zinc chloride most nearly combines the desired qualities. The tank is designed to discharge three useful functions; to prevent a straining pressure upon the window and mirror of the semi-prism, to diminish the deviation of the light, and to render changes of temperature in the bisulphide of carbon slow. The mechanical part of the arrangement is of the simplest kind. A motion of the prism round a vertical axis will bring all parts of the spectrum under review In the field of view will be seen both the spectrum and the patch of the back of α, to which β is cemented. β should extend a little more than half way along the height of α, and then by very slightly tilting the mirror *M*, the vacant patch, and the lines of the spectrum will be seen as in the adjoining woodcut.



The diameter of the mirror is to be twenty-one centimetres, and the other parts in proportion. This gives forty-two as the standard power, and we expect to obtain with it a dispersion of between 250



and 300—the dispersion of the Dublin Society's spectroscope being about eighty.* Mr. Burton has undertaken to make the object mirror, and Mr. Grubb will make the prism, the window of the tank, and all the rest of the apparatus.

An instrument constructed in the same way, but with its semi-prism built up of wedges of flint glass, cut out of the disks manufactured for object lenses, with castor oil between them, would appear to offer great advantages as a spectroscope for making accurate measures. For the observer could at once tell which line is in minimum deviation by its coincidence in the field of view with the middle of the vacant patch; and the position of the prism, which is the only moveable part of the apparatus could be read off with the precision of an astronomical observation.

XXXIII.—Discovery of Fish-remains in the Alluvial Clay of the River Foyle, with Observations on the Existence and Disappearance of an Upper Lough Foyle, and on the former Insulation of Derry and of Inishowen. By G. Sigerson, M. D., Ch. M., F. L. S.

[Read June 26, 1871.]

The discovery of organic remains in alluvial deposits, whilst generally of value, is in the present case of peculiar interest, as their apparent absence from such deposits in the locality has attracted comment. In the geological portion of the Ordnance Survey of the adjoining county of Londonderry, Captain Portlock thus wrote:—"As yet no shells, either fresh-water or marine, have been found in the detritic gravel or clay of this parish [of Templemore]. In other parts of Ireland, marl, abounding in fresh-water shells, is frequently the substratum of the smaller bogs, establishing fully their former lacustrine state, which is further supported by the occasional discovery of ancient canoes within them. Under the larger bogs, clay or gravel, without shells, is more commonly found; but before the full bearing of this deficiency on the question of formation can be estimated, the bottoms of existing lakes should be carefully examined in all positions, and under all circumstances, and the abundance, scarcity, or total absence of shells in the shingle of the present sea or lake shores, carefully ascertained at various points and under various conditions." Then, referring to the valley that bounds upon the west the hill on which the fortified city of Derry is situated, he remarks:—"Indeed, as regards this immediate parish, the insulated valley of Derry, or Mary Blue's Burn, seems a stepping stone in the inquiry, as it can be nearly proved from history to have been a channel of the river; and yet it still exhibits a bottom of gravel and clay without shells—a circumstance in some measure to

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* The beam of light in passing through the prisms of this spectroscope is higher than it is broad; so that if estimated by the height, the standard power would be nine, and the dispersion 108; if estimated by the breadth of the pencil, the standard power would be five, and the dispersion, 60. The instrument, therefore, should be credited with a dispersion which lies somewhere between 60 and 108.

have been expected, as the current running through it was probably strong enough to render it an unfavourable habitation for molluscous animals: at present, therefore, the subject must be considered strong in the evidence of external characters, though as yet only partially supported by that of existing organic remains. That this valley has probably been a water-course may be judged from the following excavations:—

"1st Excavation, 2ft. 6in.—Surface loam, with pebbles of mica, slate, and quartz.

"2nd Excavation, 2ft. 8in.—The same result as in the 1st; then blueish, tenacious clay, with thin gravel.

"3rd Excavation, 2ft. 12in.—The same result as in 1st and 2nd; then coarse gravel. Underneath, a finer gravel, mixed with sand."*

No animal organic remains whatever appear to have been found, as none are recorded. However, the thin stratum of tenacious clay which he describes seems to have the same nature, origin, and age as the alluvial deposit in which, farther up the river, the fish-remains have been discovered. The deposit of clay lying on both sides of the present river channel, where these remains were found, is incomparably more copious and extensive than at Derry, and evidently subsided in the quieter waters of a lake, now vanished. The fish-remains were found in the following manner, on the right side of the river, about nine miles south of the city of Derry, two miles north of Strabane, and half a mile east of the present river-current.

Whilst certain labourers, near the village of Ballymagorry, were digging up clay for brickmaking, they came upon some small bones. The depth at which they were found was about twenty feet beneath the surface of the clay, from which generally a layer of peat, a few feet thick, has first to be removed. Pits for brick-clay are to be seen on the landward edge of a floe-bog, which, extending in breadth for some half a mile, is bounded by the River Foyle on the west. On the opposite, or Donegal side of the river, a stratum of the same clay is to be found. These bones were regarded as forming the skeleton of a bird by the labourers, who divided them, as curiosities, among themselves. This proves the exceeding rarity of such organic remains in the alluvial deposit in question; and, so far as I could ascertain, no other relic of life had ever been met with in excavating the clay-pits.

The bones, which are now of a deep chestnut colour, and still retain some of the clay in their interstices, are manifestly portions of the skeleton of a moderately large fish. The determination of the specimen is rendered difficult by the imperfection of the skeleton; but, from what attention I have been able to give to the matter, I am induced to form the following opinion. Belonging as it does to the division of Osseous fishes, we must yet exclude both Acanthopterygii and Malacopterygii apodes. The Malacopterygii abdominales give us, as possible individuals, the salmon, trout, and pike. The non-discovery of

*Ordnance Survey of the County of Londonderry. Dublin: Hodges & Smith, 1837, vol. i., p. 6.

teeth is sufficient to exclude the latter, of which they are the strong point. The bones are too large for the trout; and on comparing the vertebræ with those of the salmon the distinction is unmistakable. From the families of the Order Malacopterygii sub-brachiati we must choose the Gadoids. On comparing the vertebræ with those of one member of the family, the codfish, they were found to correspond exactly. Whilst the pike, a river and lake fish, has been captured in the salt water below Derry, the codfish, I am informed, has sometimes come up above Derry with the tide, which ascends for many miles. Other Gadoids, the ling and whiting, have been captured in the estuaries near the city, and twenty miles from the main ocean.

The discovery of these fish-remains, and the character of the deposit in which they were found, combine to show not merely that there used to be water here, but that this water was other than an ancient channel. The presence of a lough, extending over half a mile in width from the present river, is indicated. The physical conformation of the place supports this view. The ground slopes suddenly in parts, forming a bank which appears to have been the shore of the lake. Almost from its base a floe-bog extends for over half a mile to the river channel; and beyond the river, bog and alluvial clay indicate that the lough was enlarged more widely still. Its longer dimension was north and south, in the direction of the present river; and in its course it appears to have been narrowed in places, and again to have widened out over the low levels. On looking north towards Derry, from Strabane Railway Station or Lifford Bridge, little power of imagination is required to revive the ancient scene. The hills and shelving shores enclose a vast and level expanse of bog and alluvium, through which the river winds, as though a living current were sweeping through the congealed waters of a great lake.

The height above sea-level of the floe-bog, beside and beneath which this brick-clay is found, varies, near Ballymagorry, from 16 feet to 40 feet, according to the figures set down on the Ordnance Survey maps. If we examine the low ground bounding the river at both sides from Derry to Strabane, we find the following figures given as showing its elevation above sea-level in different parts:—16 and 20 near Derry; 12 and 15 higher up; 50 in one place, which probably was once an islet; 20 at the mouth of the Dennet; 16 at Corkan Island; 16 at Island More; 18 and 13 near Strabane. Above Strabane and Lifford we have it 22 feet; and along the banks of the Finn River at 16, 17, 14, 15 toward Castlefinn, where it is 19 feet. The floe-bog, indeed, lies between Strabane and Londonderry; but gravel pits are to be noticed in many other places near the rivers, and the brick-clay is discoverable as far as Castlefinn. The preceding facts and figures combine to demonstrate that at a very recent period, geologically considered, in place of the present River Foyle, there extended from Strabane to Derry a long firth or irregular lake, of varying widths. Several islets studded its surface, jutting creeks ran in amongst the thickly-wooded shores, and a principal arm of the lake reached westwards as far as the place where now stands Castlefinn. This now va-

nished lake may, for the sake of distinction, be called Upper Lough Foyle. Taken in connexion with the Lower Lough (to which modern map-makers restrict the name of Lough Foyle), the whole expanse of water presented the form of an hour-glass, being narrowed at Derry. The Hill of Derry, however, then stood separate from the mainland, and formed an island in the middle of the connecting strait.

It is worth observing that this hour-glass form characterizes several Irish lakes, and, with respect to two lakes in the immediate vicinity, this Foyle Lough must have resembled Lough Swilly, only that it was larger, and Lough Erne, only that it was tidal.

The question naturally arises—"Was Upper Lough Foyle in existence within the time of historical record?" The answer must be in the affirmative, and the fact of its existence in historical times is not without importance in the identification of ancient districts, and the settlement of localities of historical events.

Tradition of the former existence of the Lough is embodied in the name of "Lough Foyle," which is still popularly given to what map-makers call the River Foyle, in its whole extent from Strabane to Derry; for to no other river, however large—not even to the Shannon, which is much larger than the Foyle—is the term "Lough" applied. The name, therefore, is not intended as loosely descriptive of the present River Foyle, but remains, as a fossil in the language, to show the former lacustrine conditions of the Foyle in this place. Dr. O'Donovan, who was not aware of this significance of the name, yet records that it was the exclusive popular appellation amongst the peasantry, when he was engaged in the researches for the Ordnance Survey, nearly forty years ago. He also cites authorities to show that it was the true ancient name of what is now called River Foyle, and remarks that his ignorance of this at first led him into one or two topographical errors, as he had naturally imagined that not the "River," but (what we may call) Lower Lough Foyle, was referred to, when the name "Lough Foyle" was mentioned.

Thus, in an unpublished manuscript volume of the Ordnance Survey (Co. Donegal, Letters, p. 153), the following passage occurs in one of Dr. O'Donovan's letters:—"The farmers of Teboyne never heard of a river called the River Foyle. Lough Foyle is the only name of the 'watter' up all the way to Liffer,* where the Head of Lough Foyle is. Here the Lough (not river) receives two rivers, the Mourne, the larger, from Tyrone, and the Finn, the lesser, from Donegal. This (Lifford) is exactly the place where the ancient Irish placed the Head of Lough Foyle, and O'Sullivan, speaking of a battle which took place at Lifferia, between O'Donnell and Dockwra's party, says that boats (phasellis) sailed up the Lake (Lacus) from Derry to Lifferia.†

* This is the popular and correct pronunciation of the name (Leithbear), now altered to Lifford.

† In the Annals of the Four Masters, a similar occurrence is chronicled as having occurred three and a half centuries before:

"A.D. 1248, Brian O'Neill, Lord of Tyrone, brought vessels from Lough Foyle

I find I was mistaken in my view of the extent of Moy Itha; it never comprised any part of Inishowen—never; it is no other than the Lagan, and its situation on 'Lough Foyle' alludes to what modern map-makers call River Foyle." He indicates a second error, also, in these words:—"And where Colgan says that 'Tir-enna is a territory in Tir-connell, *situate between two arms of the sea*—viz., between Lough Foyle and Lough Soolie,' we are to understand by this that he meant not Inishowen, which really lies between the two Loughs, but the eastern part of the barony of Raphoe, now called the Lagan (formerly Moy Itha), which lies between the arms of Lough Foyle and Lough Swilly—*i.e.*, between Lifford and Letterkenny, and which was bounded on the N.N.E. by the peninsula of Inishowen."

Tir-enna, it is obvious, did "really lie" between two Loughs, at a time (as I point out) when Upper Lough Foyle was still in existence, and that existence is plainly indicated in the citations given. It is further shown in the name of a place called Murlog, near Lifford, as the appellation signifies a "sea-cove." In the year 1600, Sir Henry Dockwra mentioned the name "Lough Foyle" as being that commonly employed. In Queen Elizabeth's Inquisitions, dated Derry, 23rd Nov., an. 1545, mention is made of "the royalties and fisheries of the lake or river called Loghfoile;" and, again, we have it in the statement that "the island called Inshcorri, in the river or lake of Loghfoile, near the village of Liffer, likewise belongs to the said Queen, as a parcel of the possessions of said monastery of (Colum killy), or house of the Canons of Derry."

Fortunately, in the *Maps of the Escheated Counties in Ireland, A.D.* 1609,* there is positive and distinct evidence that the "Lake of Loghfoile" was at that date different in size from the present river. It was much broader and contained more islands.

On the modern maps of the Ordnance Survey, the River Foyle is found to be only a quarter of a mile in width, when measured by scale, even when the measurement is taken at the greatest divergence of its channels, and across two islands, Oilen-more and Oilen-beg, at Disert. Now, in a map of the escheated county of Tyrone, and drawn to scale, the "Lake of Loghfoile" is laid down at *a mile* in width, and this width is continued for the distance of four or five miles below Strabane. The map is carefully set out, for confiscation purposes, and there is not much probability of a gross error in these dimensions, more especially as this part of the Lough is marked down as "The Salmon Fisheries," and would, therefore, be attentively examined. Besides, we have a second test, in the number of islands.

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into Magh-Itha, and across Termon-Daveog, until he reached Lough Erne, where he committed great depredations and demolished a castle."

The Head of the Lough, at Strabane and Lifford, was then, in fact, regarded as a seaport. This is evident from the facts mentioned, from the name of a place near Lifford, Murlog (*cf.* Mur-bholg, now Murlough Bay), or sea-cove, and from the appellation anciently given to Lifford, Port-na-tri-namhad, afterwards Portnatrynod, signifying the "port of the three enemies."

* Ordnance Survey, Southampton, 1861.

The modern map lays down two comparatively large islands, "Islandmore" (*recte* "Oilen-mor," *i.e.* Great Island) and "Corkan Island," a much smaller isle, "Island-beg" (*recte* "Oilen-beg," *i.e.* Little Island), and a yet smaller islet, called "Yew Island"—that is, four islands, of which two are very small. Now, the Escheatment Map of Tyrone shows five islands in the mile-wide lake. Two of these are small, and three comparatively large; and, in addition to these, in Map No. 16, a sixth island is placed between Liffer and Strabane. Thus two islands have lost their insular character, on account of the water-courses between them and the mainland having been filled up.

Of these two, one was that island lying at the Head of the Lough, between Strabane and Lifford. On the Escheatment Map, the Castle of Strabane is laid down as close beside the east channel, and its position seems to have been selected in order to command the ford. But through the choking up of this channel, and the consequent connexion of the former island with the Strabane territory, this reason for the selection of the site is no longer so obvious, seeing that the west channel at Lifford, now the only channel of the river, is at a considerable distance from Strabane Castle. The interference of man, no doubt, perfected the obstruction of the east channel, as the town of Strabane enlarged. One bridge thus sufficed, and ground was gained. But it is to be remarked that at times of high flood the escapement by one channel is scarcely enough, and the river, trying to reconquer its second channel, lays part of the town under one or two feet of water, and even puts in an appearance beside the Castle.

From this ex-island* at the Head of the Upper Lough, the transition to Derry at the other extremity is natural, as there is evidence to demonstrate that this place also was once an island. At a first glance the statement seems rash, for the valley through which the channel should have gone, in order to insulate the city, is now dry and firm ground, covered with habitations, and not even subject to those inundations which still testify to the former existence of a second channel at Strabane. The names, "Cow-bog" and "Bogside," applied to this locality, indicate, however, that there was a well-remembered time when this valley was a morass. Following the matter up, in order to determine, with as much accuracy as possible, the periods of change, so desirable from a geological as well as from a historical stand-point, proof is got that two centuries and a half ago the now firm ground was a wet, almost impassable bog. For, in 1600, Sir Henry Dockwra, in his "Narration of Services," wrote:—"On the 22nd May wee put the army in order to marche, and, leaving Captaine Lancellot Atford at Culmore, with 600 men, to make up the workes, wee went to the Derry, 4 miles off upon the river side, a place in the

* Having since re-visited the locality, I find that the angle of land immediately above the meeting of the rivers Finn and Mourne still retains the name of "the island." It is now no longer insulated (except during floods), but men live who recollect the existence of the vanished channel. This fact testifies to the accuracy of the Escheatment Maps. The angle islet was probably part of a larger isle.

manner of an island, comprehending within it twenty acres of ground, wherein were the ruins of an old abbay, of a bishopp's house, of two churches, and at one of the ends of it an old castle, the river called Loughfoile encompassing it all on one side, and a bog most commonlie wet, and not easilie passable, except in two or three places dividing it from the maine land." Thus, in Dockwra's eyes Derry presented an insular appearance, although what had been the west channel was then a wet marsh.* Proceeding still further back we discover that some half century before, Derry was distinctly known as an island. Thus in Queen Elizabeth's Inquisition, dated Derry, 23rd Nov., an. 1545, mention is made of "a certain parcel of land, called the *Island of Derry*." The fact that as this "Island of Derry" lost its insular character, it also gradually lost the name of island, is a proof that when that appellation was given to it the term was truly applicable. Captain Portlock's excavations furnish the geological links necessary in the chain of evidence.

The ex-island at Strabane enjoyed its insular character two centuries ago; three centuries ago it may be held certain that Derry was also an island. Thus there was an island at the head, and another island at the foot of the Upper Lough, both of which have since become connected with the mainland. The insulation of Derry added another to the number of islands already mentioned, so that three hundred years ago there were at least seven islands in Upper Lough Foyle; and as the lake was more extensive at that period, some knolls on its banks must also have increased the number, by their insulation.

Next comes the question of the former insulation of Inishowen, the great peninsula which lies between Lower Lough Foyle and Lough Swilly, its neck being near Derry. The name signifies the Island of Eoghan, but so firmly is its peninsular character established that no idea of its insulation, within historical times, appears to have been conceived. People have preferred to do violence to the name or to its aptness, regarding it as loosely applied, or only employed for want of a more appropriate Irish word, which, however, exists. Nevertheless, I am bound to declare that it was once, within historical times, a perfectly accurate appellation.

Having satisfied myself as to the former existence and extent of Upper Lough Foyle, and noted the various elevations of the soil where once its waters flowed, I examined its vicinity for traces of contemporary changes. It seemed not improbable that there had existed also other features in the landscape, since obliterated likewise. My attention was immediately arrested by a remarkable impression, or furrow, so to say, which runs from an inlet of the Swilly, a little north of Burt House, past Dunberry Hill, between Elagh and the Grianan to the Foyle, at Pennyburn, near Culmore, a little north

* This swamp is marked in Neville's Map of the Siege, 1689. A stream ran through it, northwards, into a slob, which, occupying all the space known now as "Waterloo Place," extended to the "Cowards' Bastion" and "Corn-Market." The slob also bounded "Water Bastion," so that Foyle street now partially covers its site on the southern side.

of Derry. At various places along this hollow the figures 18, 28, 28, 29, 32, 36, 37, marked its heights above the level of the sea at low-water (the tide rises nine feet in Lough Foyle). Now, these heights were no greater than those recorded for the soil beside the (Upper) Foyle, where water once flowed. The physical appearance and geological character of this furrow that crosses the neck of the Inishowen peninsula were next found to support the inference that it might have been a water-channel at the time of the existence of the Upper Lough Foyle. Captain Portlock well described the characteristics of this district (Ordnance Survey, Art. *Detritus*). The principal locality of the deposits which came under the head of Detritus lies about and includes Culmore. It runs inland (or towards Swilly) from the Foyle; its edge is defined by the rise of the Schist range, the termination of which is covered with gravel. "The inner part of this spacious flat is bog, resting on clay," he observes; and here again the resemblance to the Upper Foyle is marked. The edge at Lough Foyle is composed of thin horizontal strata of sand and pebbles. In other parts, this arrangement is not observed in the detritus; the sand or gravel is heaped along the sides of valleys, the bottoms of which are flat bogs resting on level clay. "The union of these two forms of detritus impresses strongly on the present surface the character of ancient water-courses, either lakes or rivers. The detritus of gravel narrows and defines the boundaries, while the level clay base contributes to give the boggy covering that uniformity of surface which characterizes the tranquil water of a lake." Such appearances may be observed in the valley which contains the bog of Shantallon, and bog and lake of Ballyarnet, where a chain of isolated sand hills may also be seen, up whose sides the bog has crept. Some of their summits have been capped by it within the memory of man.

Then the furrow which crosses the neck of the peninsula is thus accurately described:—"In the still more marked depression which, constituting the valley of Pennyburn, extends, with little variation of level, towards Lough Swilly, the appearances are equally illustrative; for, in advancing towards the west, the valley is narrowed between two beds, or islands of rocks, and exhibits a channel so natural and well defined that it is impossible to resist the feeling of being in a river or strait—an effect which is greatly heightened by the level, smooth, and now grassy bog, which lines the bottom. The channel again swells into an open basin, and is again, for a short distance, contracted, as it winds round some projecting rocks, which seem to attest, by their isolated position, limited extent, and low level, that some powerful agent, such as water, had long exercised on them its abrading influence. The curious sandhill, called Dunberry Hill, is in the prolongation of this valley, and bears the same relation to it which those previously described bear to the valley of Ballyarnet."

On investigating the subject historically, I find that portion at least of this transverse valley appears to have been a mere wet marsh in the nineteenth year of James I. In an inquisition made that year, mention is made of a boundary marked by a river, "which river crosses over

through the morass as far as Lough Swilly aforesaid," while, "from the causeway of Ellaghe, as far as Lough Foyle aforesaid, is through the midst of a morass tending to Lough Swilly as aforesaid." Thus, it would appear, at that date, to have presented characteristics identical with those which Dockwra describes as distinguishing the channel-valleys of Derry twenty years before. The furrow across the neck of the Inishowen peninsula might therefore have served as a channel, or water-course, insulating Inishowen even later than the closed Derry channel.

Now, bearing these facts in mind, it is exceedingly curious to discover that in the Escheatment Maps of Ulster, A. D. 1609, the Foyle and Swilly are shown connected by a channel; and this watercourse runs exactly in the direction indicated, for it proceeds from an inlet of Swilly, a little north of "Bert Castle," south of "Elowh Castle," and joins the Foyle a little north of "Derrie." A second but imperfect channel is even shown as connecting the Swilly and Foyle south of Derry; it runs from the north side of "Kilmakatrem Castle" to the south side of "Cargan" (now Carrigan). Aileach would thus have been insulated. With this, however, we have nothing to do, nor with the insulation of Malin, also marked,* corroborative evidence not being readily attainable. The establishment of the former existence of one channel suffices to prove that Inishowen was really an island within historical times.

Additional proofs of its insulation may be found in the Irish Annals, and confirmation in its ancient political geography. Thus, although Inishowen is united, both politically and geographically, with the county of Donegal, it was of old disconnected from it in both ways. Inishowen formed part of Tyrone, politically, and the connexion between them still continues ecclesiastically, as the diocese of Derry includes Inishowen, Derry, and Tyrone, taking in both margins of the Foyle as of old. Named Eoghan's Island, after Eoghan, son of Niall of the Nine Hostages, who was buried there, at Iskyheen, the Irish annalists repeatedly and emphatically distinguish it as an island. This is observable in the following extracts from the Four Masters:—

"A. D. 1211. Thomas Mac Uchtry and the sons of Randal Mac Sorley came to Derry, with a fleet of seventy-six ships, and plundered and destroyed the town. They passed thence into the island of Eoghan (Inishowen), and ravaged the entire island."

This is clear, but so strong is the modern impression of the peninsular character of Inishowen, that Dr. O'Donovan, in his translation, adds the words ("*recte*, peninsula"). However, the Annals give no countenance to this alteration, as may also be seen from this passage:—

"A. D. 1010. Oenghus O'Lappan, lord of Cinel Enda, was slain by Cinel Eoghain, *of the Island*," i. e. Inishowen.

Thus the epithet which distinguishes that portion of the Cinel Eoghain from those dwelling east of the Foyle was founded on the fact that the insularity of Inishowen was then notorious. "The Island"

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* In the map of "The Kingdome of Ireland" (a *fac-simile* of the original) attached to *Pacata Hibernia* the channels insulating Malin and Inishowen are also marked.

suffices to point out the locality, as there was no other to compare with it in size. So, after it had become connected with the mainland, the appellation of *Inch* (Inis, the island) was popularly transferred to an isle in Lough Swilly, which, though extremely small in relation to it, was large when compared with some others. Inch, however, has become a peninsula in quite recent years. In 1836, the sands between it and the mainland had so far accumulated as to permit of a passage across, at low water, along the strand road. When a deposit of detritus had advanced so far as to make reclamation profitable, human interference completed the isthmus. *Inch* now is no longer an island, though still marked as such upon the maps.

The considerable elevation above water to which sands may attain is well shown at the Erne estuary, at Ballyshannon, where the sandy strand varies from 5 feet at Coolinargit and Ballass to 150 feet near Finner East, where it ascends to 192 feet.

It is not, therefore, strange that the channels described should have become choked up, least of all that which united Lough Swilly to Lough Foyle. The sand hills are readily accounted for; even the tallest of them, Dunberry Hill, is only 79 feet high. The deposit of detritus in the channel was supplemented by the growth of bogs above it, and the rapidity with which this may proceed may be judged from the statement by Mr. Griffiths, in his "Bog Reports," that he observed one bog grow two inches each year during twenty years. Thus a bog might have grown four feet in a quarter of a century, under favourable circumstances.

It is possible that there may have been partial upheaval of the land. That this north-western district was subject to disturbance of levels within historical times may be inferred from statements in the Annals, and from certain physical facts. Thus, I observed deep in a clay pit the stump of a tree; it was impossible to discover with certainty, but it seemed probable, that it had been growing in the spot, when, owing to a subsidence of the land, the waters rushed over the place, broke it, and buried it slowly with silted soil. Now, the Annals, A. M. 3581, do countenance such an occurrence, as they chronicle the "eruption" of Lough Foyle in that year. Again, A. M. 3751, it is related that a Firbolg tribe, the Ernai, were defeated on the plain where Lough Erne (which takes their name) now is; after their defeat the lake flowed over them. And, Professor W. K. Sullivan communicates the remarkable fact, that twenty feet beneath a bog surface, at Pettigo, near this lake, the skull of a dolphin has been lately discovered. This indicates that the sea once overflowed that locality, through subsidence of the land. That there has been upheaval since is proved by the surface of Lough Erne*

* "I passed over the grand cliffs that overhang the plain of Fweealt of Toorád. This Fweealt is a level district running about five miles along the N. W. banks of the great Lough Erne. The name ('Faoi alt') signifies under the height, subrupian. It is grand and beautiful, and seems to have been formed when the awful commotion took place that formed Lough Erne. It was by a depression of the earth, occasioned by some subterranean commotion, similar to the one that in later times destroyed the city of Lisbon."—Ordnance MSS., Fermanagh. Letters, p. 41.

being at present elevated 149 feet 9 inches above the level of the sea at low water. At the period of its elevation the upheaval may have extended to the Foyle basin also.

Still it is scarcely needful to cite such a cause, even as assisting in the obliteration of Upper Lough Foyle and the adjacent channels. The deposition of the travelled gravel and silts of which the tributary and often-flooded rivers and torrents were the vehicles, would proceed at no inconsiderable rate in such a lake. The great alluvial tract formed by the Rhone at the head of the Lake of Geneva, the removal of the lake margin to the distance of a mile and a half in eight centuries from the town of Port Vallais, the gradual filling in of the estuaries of the Forth, Tay, and Humber, and of the Lee at Cork, all show what changes may thus be caused. Then the closing up of the west channel at the Island of Derry, by throwing all the weight of water on the east channel, caused it to be excavated to a greater depth. Four miles above Derry the river depth is only 22 feet; quite near it is only 24 feet; while at the midst of the east channel it is 43 feet.

This lowering of the escape channel would be followed by a lowering of the lake surface at ebb tide; and thus, by the partial uncovering of deposits, conditions favourable to the formation of marshes and growth of bog would be presented. The destruction of the forests, with which the locality was anciently well provided, would help in this respect, by diminishing the rainfall and decreasing the volume of the tributary streams.

The obliteration of lakes, of which some examples in recent years have been noticed by geologists, has been several times mentioned by the ancient Irish annalists. And it is of importance, alike to geology and to history, to find that traces of the effaced lakes are yet discoverable, and that the methods to which their effacement was attributed by the Annalists have been observed, in recent days, still in action. The following list contains the names of the principal vanished Irish lakes:—

1. *Burran.*—The Island of Lough Burran was captured by O'Donnell, A. D. 1544. The lake is now dried up, and "the place called Loughaverra," in the parish of Ballintoy, county Antrim.—O'D.

2. *Cre.*—This lake was last mentioned in the Annals A. D. 1143. Cambrensis calls its island "*insula viventium.*" A church was built on it. This lake is also dried up, and the ruins of the church are to be seen "in the middle of a bog in the townland of Monahinsha" (bog of the island), parish of Corbally, county Tipperary.—O'D.

3. *Feabhail.*—Lough Foyle, already described.

4. *Gabhair.*—The formation, or "eruption," of this lake is chronicled as having occurred A. M. 3581. The Loch and its islands are mentioned A. D. 933. It is now dried up, but the place still bears the name of Lough Gower, or Logore, in Meath.—O'D. The discovery of antiquities is recorded in "Proceedings, Royal Irish Academy," vol. i.

5. *Gair.*—Lough Gur, as it is now called, was last mentioned in the Annals in 1599. It contained one large, well-fortified island, and

a couple of small ones. Sir George Carew relates that the Lord President of Munster viewed it in 1600, and "Hee found it to be a place of exceeding strength, by reason that it was an iland, encompassed with a deep lough, the breadth thereof being, in the narrowest place, a caliver's shot over; upon one side thereof standeth a very strong castle, which at this time was manned with a good garrison, for there was within the iland John Fitz-Thomas, with two hundred men at the least." This island is now connected to the mainland by a broad tract of firm soil and turf-bog. The waters of the lake have fallen, and are decreasing; but Mr. G. Martin informs me that the ex-island is yet popularly known as the "Big Island." A great quantity of bones of animals has been found in this lake.

6. *Laeigh.*—"A. D. 848, Loch Laeigh, in the territory of Umhal (Mayo), in Connaught, migrated," say the Four Masters. Nennius adds that it ran off into the sea, and that nothing remained of it but its place. He sets this down as one of the Wonders of Ireland.

7. *Laeghaire.*—This lake is mentioned as existing in 1509, south of Strabane, Co. Tyrone; "the name is obsolete, and the lake has probably been drained."—O'D. The Escheatment Maps of 1609 do not show it.

8. *Monann.*—It is stated that, A. D. 1522, O'Neill pitched his camp at Knockavoe, at Loch Monann, where he was defeated by O'Donnell. In the Book of Ballymote, the conflict is called the "Breach of Loch Monann." O'Donovan mentions vaguely that this was the name of a lake at the foot of Knockavoe. I could find no trace of it, until, by the Escheatment Maps, 1609, I discovered that a townland above Strabane was then named "Loughmonan." The lake was not marked, and had then probably vanished. In what manner? It appears to have lain at the head of the picturesque little ravine called "Strabane Glen," and I believe that this lake also "migrated." From the physical evidences presented, it seems to have broken bounds (when overflowed by heavy rains), and, ploughing a deep furrow through its old-detritic barrier, to have thus formed "Strabane Glen," escaping from which its waters divided and poured into the Upper Lough Foyle. The detritus it bore assisted in the filling up. A sketch of the Glen, from the upper end (taken previous to the existence of the present plantation there), preserved in the Academy, plainly confirms this view. It may be added that a vague memory of the outburst might account for a traditional prophecy that Strabane was to be drowned by waters breaking out of Knockavoe.

9. *Suidhe Odhrain.*—It is related by the Four Masters that, in 1054, this lake "migrated in the end of the night of the festival of Michael, and went into the (river) Feabhaill, which was a great wonder to all." The name still remains as that of the townland of Syoran, parish of Knockbride, Co. Cavan.—O'D.

The quiet effacement of some of these lakes was due, in part, to the destruction of woods, which, as Humboldt remarked, protect the soil from the sun, hinder evaporation, condense moisture and exhale it. The felling of forests has in several places lessened the rain-fall, and

caused streams to dry up. Thus Rio Janeiro, as Gardner states, had its climate changed from wet to dry, and the Brazilian Government was forced to forbid the felling of the trees on the Corcovado range, through a new fear of drought. The growth of bog assisted largely in lake obliteration. Subterranean channels must also be counted.* Moorlough, near Strabane, I have seen emptying itself into a subterranean channel, until the aperture was banked up by the mill-owners. This channel might have been the precursor of an outbreak, by which the gravelly bank would have been swept away, and a little glen or ravine formed.

As to the "migrations" which have excited wonder and some doubt, they are quite in conformity with the well-attested facts of recent times. Thus, they find a parallel in the outbreak of the lake near Martigny, in the Vallais, the escaping torrent of which traversed the forty-five miles to the Lake of Geneva in five hours, destroying all in its course. Another instance occurred in 1810, in Vermont, U. S., when a lake, a mile long and three-quarters of a mile wide, broke its barrier, ploughed a vast furrow into a lower lake, burst bounds again, so that the waters of both lakes excavated a channel thirty feet wide, and from twenty to sixty feet deep, through a valley five miles in length. The confirmation thus given in many points to the Irish Annals by the facts of geology, lends an additional interest to their curious chronicles of the eruptions of rivers and lakes in pre-Christian times. Such occurrences would show that Ireland was, of old, remarkably subject to earthquakes. And it increases the reasons for crediting the chronicles to learn that a vivid tradition is still preserved in Sligo of an earthquake which, the Annals say, resulted, so late as A. D. 1490, in the production of Meemlough (i. e. the eruption lake),† and in the destruction of a hundred men and much cattle. It is obvious that the confirmation of the chronicles and the physical facts pointed out may prove of importance in defining or limiting the antiquity of animal remains or of relics of human existence. It is conceivable, for instance, that objects found deeply buried in detritus, and regarded as extremely ancient, might owe their interment (at a comparatively recent period) to the furrow of a burst lake or the deposit of a river which had changed its channel.

* The public press mentions the disappearance, in the present year, of a large lake in Lithuania, district of Telchef; it measured eight versts by five, and its fishery was worth 15,000 roubles annually. During a calm, its waters rose and seemed as if agitated by a tempest. A sulphurous smell was perceived, and the lake became covered with dead fish. Then the waters began to sink (the sulphurous odours increasing), until the lake-bed was almost dry.

† *Cf.* "In England, in 1755, a pond in the town of Luton, in Bedfordshire, in which there had been but little water for some weeks, suddenly filled, and a copious sediment was thrown up from the bottom, at the precise time of the earthquake at Lisbon, the water continuing too verflow for some hours."—Griffith's "Bog Reports," p. 176; 1810. The Irish Annals say that, at Meemlough, there were "many putrid fish thrown up," a statement which, bringing the occurrence to a close resemblance with that in Telchef, may indicate the previous existence of a pond or pool.

XXIV.—NOTE ON THE GREAT DOLOMITE BED OF THE NORTH OF SPAIN, IN CONNEXION WITH THE TITHONIC STAGE OF HERR OPEL. By Professors W. K. SULLIVAN and J. P. O'REILLY. With Plate XVIII. (Science).

[Read June 12, 1871.]

EVEN where there is no lack of fossils, the determination of the boundaries of the cretaceous and jurassic periods is beset with difficulties. In the south of England the fresh-water beds of the wealden indicate, in the clearest manner, a break in the succession of marine deposits; while in the Carpathians, Alps, the south of France, &c., the rocks of both periods are perhaps wholly marine. If we could recognise every link in each series, so as to obtain an unbroken succession of marine deposits from the bottom of the jurassic to the top of the cretaceous rocks, much light would, no doubt, be thrown upon the great biological question of the changes which take place in long periods of time in the character of species. Much remains, however, to be done before the regular, unbroken succession of the rocks of these periods can be made out. The chief difficulty lies in what may be called the passage beds between the two periods.

Between the base of the chalk—the étage valenginian, and the couches de Berrias—and the upper jurassic beds characterized by Opelia tenuilobata, or Professor Hebert's zone of Ammonites polyplocus, occur a number of such passage beds between the cretaceous and jurassic periods, but more closely related to the latter than to the former. These beds were more or less noticed at different times by various Swiss and German geologists, but Herr Opel having devoted special attention to them, and having bestowed on them the name of the "Tithonic Stage," they assumed an importance which they did not previously possess.

Rocks of the Tithonic Stage are found in the Carpathians, the Austrian and Bavarian Alps, Switzerland, the south of France, Italy, and, probably, in the Sierra de Cabra, in Andalusia. Herr Zittel, who has described the fauna of the stage as it occurs in the Carpathian Mountains, recognizes two zones—the lower, or "Zone of Terebratula diphya," which is everywhere in contact with the "Zone of Ammonites tenuilobatus;" and the upper, or "Zone of Terebratula janitor." The two series occur in contact at Palocsa, in the Klippenkalk region of the Carpathians. To the first zone belong the Stramberg beds in the north margin of the Carpathians; the upper beds at Palocsa, just alluded to; the Auerkalk of the Vorarlberg, the argillaceous limestones or Calcaire Supérieur of the Porte de France, and other places in the Departments of Isère, and Basses Alpes, a white non-fossiliferous limestone from the central Appenines. At Palocsa these upper beds are in contact with the neocomian, while the Auerkalk is in contact with the valenginian. The beds of the lower zone, or that of Terabratula

diphya, occur at Inwald and Roczyny, on the northern margin of the Carpathians, at Rogoznik, Czorstyn, &c., in the region of the Klippenkalk of the same chain; at Pirgl and other places in the Austrian and Bavarian Alps; at Wimmis, near the lake of Thun; and Mount Salève, near Geneva; the coral rag of Echaillon, Mont du Chat, &c., in the departments of Isère and the Basses Alps, near Marseilles, in the Cevennes; and possibly the white and grey limestone rich in corals and gasteropods with Terebratula janitor, and T. Moravica in North Sicily, described by Professor Gemmellaro, and the red limestone with Terebratula diphya of the Sierra de Cabra in Spain.

We are less concerned at present with the eastern development of the Tithonic Stage than with its western extension. Leaving out of consideration, therefore, the Stramberg and Rogoznik beds, we shall give the conclusions of Herr Zittel, the latest writer on the subject, regarding this western extension of the stage in Switzerland and France.

1. In the region of the Hispano-Alpine Province the jurassic formations are closed above by a coralline facies whose fauna has nothing in common with the lower chalk, whilst the greatest analogy with the upper Jura may be detected.

2. All true Alpine Jura beds of this region are older than this coral rag, and, as a rule, the "Zone of Ammonites tenuilobatus" immediately underlies it, although in one place (the Simmenfluh, at Wimmis) a Myacitus-facies of the kimmeridge underlies it.

3. No palaeontological agreement with the fauna of any determinate extra Alpine jurassic horizon can as yet be determined; but from the stratigraphical relations, and the palaeontological facts, it is certain that the beds in question represent either the upper part of the kimmeridge, or the beds between the kimmeridge and the lower cretaceous formation.

We have entertained, for several years, the opinion that the Tithonic Stage may be traced still further; that the great dolomite bed of Santander, in northern Spain, forms part of it, and that the shelly limestone underlying this dolomite probably represents the "Zone of Ammonites tenuilobatus," but we delayed putting our opinion on record until we should have an opportunity of completing our former investigations on the geology of the Cantabrian Pyrenees, and especially of making a more or less complete collection of the fossils of the Santander and Asturian beds. Since we became acquainted, however, with the papers of M. Coquand, on the rocks in the neighbourhood of Marseilles* and in the Cevennes.† We are fully convinced that the dolomite belongs to the zone of Terebratula diphya, and wish, therefore, to place our opinion on record.

Before describing the results of M. Coquand's researches, and their

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* "Bulletin de la Société Géologique de France," t. xxvi., p. 100.
† *Ibid.*, xxvi., p. 834.

bearing upon the Santander rocks, we must first briefly state the position in which we left the question of the stratigraphical succession of the rocks of Santander, when we published our paper on the mineralogy and geology of that province in 1863.*

M. De Verneuil, who examined part of the country lying north of the Cantabrian extension of the Pyrenees, in 1849, came to the conclusion that one of the sub-chains in the Montaña or province of Santander, the Dobra Range, was carboniferous, and, consequently, connected with the large developments of that formation stated to exist further west in the Asturias. Against the carboniferous limestone of the Monte Dobra he found resting, as he believed unconformably, a system of sandstones, conglomerates, and blue argillaceous limestones belonging to the lias. Subsequent observations led him to regard the whole as forming part of a band of jurassic rocks, about nine miles wide from north to south, and thirty-six miles long from east to west, stretching in length from La Cabada to Fuente de Nansa. This jurassic band he believed to rest towards the west, or rather southwest, on triassic rocks—a crescent-shaped island of which it enclosed to the south of Vargas—and to pass under cretaceous rocks, except when in contact with the trias.

In our paper just referred to we not only came independently to the conclusion that the Dobra Range was jurassic, but that the rocks of that formation, instead of ending at Fuente de Nansa, as M. de Verneuil thought, extended across the River Deva; in other words, the great limestone masses of the Liebana and of the south-east of the Asturias were also jurassic. If this be so, the limestone in question forms some of the highest peaks of the Cantabrian chain, the Picos de Europa, which had hitherto been universally considered to belong to the carboniferous period.

We also showed that in the district near the coast hitherto described as cretaceous, denudation had laid bare in the valleys rocks of a jurassic character. Among these is a great bed of dolomite, in some places 120 metres thick, which we were the first to describe, and to show its connexion with the mineral deposits of the locality. We considered this bed as the top of the jurassic series, and suggested that it extended under all the cretaceous rocks of the North of Spain, which rest upon jurassic ones.

The relation of the dolomite bed with the other rocks, and its connexion with deposits of ores, was illustrated in our paper, by several sections, one of which we have given in the annexed plate, (see Pl. xviii., Science). The section here selected is that passing from north to south through the valleys of Comillas and Udias. As the scale of this section is very small, and can only show, at most, the general relations of the beds, we have added an enlarged section of

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* "Atlantis," vol. iv., p. 319; and "Notes on the Geology and Mineralogy of the Spanish Provinces of Santander and Madrid." London: 8vo; 1863.

the valley of Udias. In both sections the corresponding beds are marked with the same numbers. The bed marked No. 7, which immediately overlies the dolomite, and caps the heights at both sides of the valley of Udias, is a fossiliferous limestone, which towards the sea is covered by soft greenish sandstones. The great dolomite bed which is marked No. 8 crops out with physical characters so marked, and so distinct from any of the overlying beds, that no indications of a passage from the one to the other are recognizable. The extremely fissured state of this dolomite, and the many jagged points which are visible wherever it shows itself, are, we think, strong evidence that the upper surface of the dolomite is a surface of denudation upon which the overlying limestone was deposited. This limestone consists of thin, compact, closely-bedded, often shaly, marly or sandy beds, which present a marked contrast with the limestones underlying the dolomite, and marked 9, 11, and 12. The bed marked 10 is a shaly limestone, which yields at another point a very peculiar cement of good quality. The group of beds marked 13 consists of red shales, sandstones, and limestones, which crop out again in the valley of Cabezon de la Sal, to the south of Udias, as also on both flanks of the Dobra chain, still further south.

An important physical distinction between the rocks underlying and overlying the dolomite is furnished by the fact, that the joints which fissure both the dolomite and the underlying rocks do not seem to have extended themselves upwards into the overlying rocks, which, in this district, do not anywhere afford any deposits of ores; while the underlying beds abound in them. This discontinuity of jointing vertically is most marked, and tends to confirm the opinion that the dolomite closes the jurassic formation in this district, and that there is a gap of some extent between the dolomite and the cretaceous overlying limestone.

Our next task was to determine the stratigraphical position of the overlying cretaceous rocks. From the study of the limited number of fossils at our disposal, as well as from stratigraphical and lithological considerations, we assumed the existence of three stages of cretaceous rocks, the turonian, the cenomanian, and the neocomian. The limestone overlying the dolomite we looked upon as belonging to the latter. M. D'Archiac concluded from the observations of M. de Verneuil that the neocomian stage is wanting, so that M. de Verneuil's third stage—for he also recognizes three—would be the cenomanian.

The age of rocks can only be determined with certainty by paleontological evidence. In this district the rocks that form the base of the cretaceous and the top of the jurassic formations are, unfortunately, in such places very poor in fossils, and of those that do occur we had only very few when writing our paper. We had, however, no doubt of the jurassic character of the dolomite—as to this the evidence was satisfactory. On the other hand, we considered our classification of

the cretaceous rocks as provisional, especially as regards the lower members of the series.

We may now return to M. Coquand's investigations. According to that geologist there occurs in the neighbourhood of Marseilles a mass of dolomite of about one hundred and fifty metres thick, which rests upon the upper Oxford series. Above the dolomite come a series of limestone beds about 100 metres thick, in which are found some badly-preserved nerineas and corals. These coralline limestone beds form the upper part of the Jura, and are very sharply separated from the overlying valenginian. M. Coquand looks upon these beds as the representatives of the kimmeridge. As the badly-preserved fossils afford very little paleontological evidence this opinion must be chiefly based on stratigraphical considerations. Herr Zittel thinks that they represent exactly the beds of Rogoznik, and correspond to the coralline limestone of Inwald, Pirgl, Mont Salève, and Wimmis.

In the neighbourhood of Ganges, Saint Hippolyte, and Saumène, in the Cevennes, M. Coquand has also found a great bed of dolomite above the "Zone of Ammonites polyplocus, and A. tenuilobatus," containing, sparingly, as at Marseilles, badly-preserved fossil remains. Here, too, the dolomite is succeeded by well-bedded solid white limestone, 180 metres thick. This limestone is more fossiliferous than the corresponding one near Marseilles, being here and there filled nestwise with fossil remains. The Marseilles limestone also contains in some places, as at Cazillac, Bois de Mounier, and Rans, numerous easily-determinable fossils. The fauna of this limestone in both districts consists principally of Gasteropods, Elatobranchs, Brachiopods, and corals. The total habitus of this fauna is decidedly upper jurasic. Herr Zittel is of opinion that this limestone offers the same facies as that of the Rogoznik beds of the Carpathians, as at Inwald, Mont Salève, and Wimmis. It occupies exactly the same stratigraphical position as the diphya limestone in the Southern Alps, and the shelly breccia of Rogoznik. He thinks that the concurrent testimony of MM. Coquand and Hébert shows it to be paleontologically identical with the coral rag of Mont Salève and Inwald.

M. Coquand's description of these Southern French rocks agrees so well with the character of the Dolomite and overlying limestone of Santander, especially as seen in the valleys of Comillas, Pelurgo, and Udias, that there can be little doubt that they belong to the same horizon, and that the Tithonic Stage extends beyond the Pyrenees. If, as there is every reason to believe, the dolomite was formed in a deep inland sea, we have in this enormous fringe of rocks, included under the term Tithonic Stage, and extending almost unbroken from nearly the Black Sea to the Atlantic Ocean, evidence of the existence of a great Mediterranean Sea at the close of the jurassic period of even far larger dimensions than the present one.

Nor are the rocks included in the Tithonic Stage confined to the Biscayan coast; investigations carried out in other districts of Spain

subsequent to the publication of our memoir* seem to show that rocks belonging to this stage, and to the other associated jurassic rocks, extend over the whole peninsula, and probably crop up along the slope of the Dzurjura range of the Atlas mountains, on the African side of the Mediterranean. Indeed, one cannot help being struck at the similarity between the descriptions of the several districts thus independently examined. While on the one hand they clearly demonstrate that the age of several of the groups of rocks constituting the great mountain chains of Spain, Portugal, and North Africa remain to be definitely settled, and brought into connexion with the better studied ranges of the rest of Europe, on the other, there can be no doubt of the important position which jurassic rocks occupy among those groups. On both sides of the Mediterranean we find rocks of this period forming mountain chains as lofty as the Pyrenees, and under conditions and presenting lithological and physical characteristics which give considerable support to our views regarding the age of the Picos de Europa.

When discussing the age of the rocks composing the Picos de Europa we overlooked an important admission of Don G. Schultz, which shows that, although he coloured in his geological map the greatest part of Eastern Asturias as carboniferous, he was very far from believing that the age of the rocks of that district had been determined. Indeed, when we consider his uncertainty as to the exact nature of the silurian period, the basis, so to speak, of his whole stratigraphical scheme, the extraordinary positions which he assigns to the carboniferous rocks in many parts of Asturias, at one time unconformable, and at another conformable, or even actually interpolated in, or underlying devonian rocks, and the similar confusion between certain so-called keuper and carboniferous rocks, it is evident that the geology of the eastern parts, if not of the whole of Asturias, requires to be re-examined.

The passage in Don G. Schultz's work to which we have referred is as follows. After stating how difficult it is to distinguish in the carboniferous rocks an order of succession or of age, he says of the eastern part of Asturias :—"We cannot state with certainty that the devonian does not crop out in some one or other point of this vast mountainous region which we have gone over; it is rather to be supposed that it exists in some of its valleys or in the masses of quartzite intercalated among the beds of the carboniferous formation in the same way (or rather in the inverse) as we have seen the carboniferous formation interposed between beds of the older formation, nor

* See, among others, Coquand's Mémoire sur la province de Castillon de la Plana (Bulletin de la Société Geologique, t. xxiv., 1866-67); M. E. Jaquot, sur la composition et sur l'age des assises que dans la peninsule Iberique separent la formation carbonifère des depôts jurassiques.—*Ibid.;* M. Maris, sur les roches formant les sommets de la Grande Kabylie.—*Ibid.* t. xxv., 1867-68; Notes on the Geology of the Province of Jaen, Revista Minera, 1868, p. 311.

can we affirm that all the limestone of the summits in the said eastern region are exclusively carboniferous, it being quite possible that some of those many limestone sierras correspond, as indicated by Don Paillette with regard to Peña Mellera, to rocks over the carboniferous formation in which they are disseminated."

We have, unfortunately, no knowledge of Don Paillette's memoir beyond the notice of his opinion given here, and cannot therefore say how far his opinion directly accords with ours as to the general question of the jurassic character of the rocks of Eastern Asturias, or may have reference merely to the age of some local groups of beds.

In conclusion we hope that it will not be considered out of place if we express our satisfaction that the views which we put forward in 1863 regarding the geology of Santander, and which at the time were so opposed to much of the current opinions of geologists, turn out to be so much in harmony with all the results of subsequent investigations of the Hispano-Alpine jurassic rocks as to require no substantial modification. We trust that we shall soon have an opportunity of more thoroughly examining the region of the river Deva, the key of the geology of the whole of the Cantabrian chain, and of laying the results before the Academy.

DESCRIPTION OF PLATE XVIII.

Illustrating MESSRS. SULLIVAN AND O'REILLY'S *Paper—On the Great Dolomite Bed of the North of Spain.*

N. S. section of beds between the sea and the Valley of Udias, passing through the Valley of Comillas; twenty-three miles west of Santander; length of section, about four miles.

Bed No. 1. . Greenish, and in some points slightly micaceous grey sandstone; very soft, and yielding; contains in places pieces of amber, and also traces of fossil plants, apparently marine, very soft and yielding.

,, No. 2. . . Beds of shaly pyritic clays, with thin ripple-marked sandstone plates.

,, No. 3. . . Hard shelly limestone.

,, No. 4. . . Beds of clay containing dark grey nodules.

,, No. 5. . . Thick bed of rather friable greenish sandstone, presenting no traces of fossils, and comparatively easily acted on by atmospheric influences.

,, No. 6. . . Thin beds of marly clay, containing nodular limestone, and abounding in fossils (oysters, trigonias, &c.).

,, No. 7. . . Limestone beds of dark grey colour, the planes of stratification being generally marked by thin layers of black marly clay, and containing *Orbitolina concava*, Lam., *Rhynconella depressa*, d'Ord., and *Terebratula menardi*, Lam. This would represent the lowest bed of the cretaceous formation immediately overlying the dolomite.

Bed No. 8. . . Great bed of hard brownish-grey crystalline dolomite, extremely fissured and weather-worn where exposed, intimately associated with the zinc deposits of the province.

„ No. 9. . . Dull-grey non-crystalline limestone, also much fissured, containing extensive deposits of white hydrated silicates and carbonates of zinc, and a great variety of hydrated clays. In some points it presents compact beds of large oysters, and in it occurred the remarkable deposit of hydrosilicate and carbonate of zinc, enclosing bones of quaternary animals partially altered into phosphate of zinc.

„ No. 10. . . Bed of dark blueish-black limestone, which forms the bases of No. 9. It furnishes a cement of a rich light cream-yellow colour; is nearly yellow after calcination, and of a first-rate quality.

„ No. 11. . . Beds of slate clay and greenish sandstone, often very micaceous.

„ No. 12. . . Thick beds of light-grey compact lithographic limestone, containing deposits of hydrocarbonates and silicates of zinc. They are much broken up by jointing, and eroded into cavities or caves. It contains a great abundance of fossils.

„ No. 13. . . Beds of marly clays, red sandstones, and thin limestones, the red predominating, and being associated with gypsum and salt in the Valley of Cabazon de la Sal.

The numbers in the enlarged section represent the corresponding rocks of the smaller one.

XXV.—THE THEORY OF SCREWS.—PART I. A GEOMETRICAL STUDY OF THE KINEMATICS EQUILIBRIUM AND SMALL OSCILLATIONS OF A RIGID BODY. By ROBERT STAWELL BALL, LL. D., M. R. I. A. [Abstract.]

[Read November 13, 1871.]

THE following are definitions of special senses which are attached to certain words used in this paper. A *screw* is a line in space with which a definite linear magnitude termed the *pitch* is associated. The pitch may have any length from + ∞ to − ∞. A body is said to receive a *twist* about a *screw* when it is rotated about the *screw* through the *angle of twist*, and is at the same time translated parallel to the *screw*, through a distance equal to the product of the *pitch* and the *angle of twist* expressed in circular measure. If the pitch be zero the *twist* is a pure rotation; if the pitch be infinite, the *twist* is a pure translation. The motion of a body implied by the word *twist* is the motion of a nut upon an ordinary screw. A *wrench* about a *screw* denotes a force (*the wrenching force*) and a couple (the *wrenching couple*). The force is directed along the *screw*. The axis of the *wrenching couple* is parallel to the *screw*, and the moment of the *wrenching couple* is the product of the *wrenching force*, and the *pitch* of the *screw*. If the *pitch* be zero, the *wrench* is a force only. If the *pitch* be infinite, the *wrench* is a couple only.

A body can be transferred from one position in space to any other position in space by a *twist* about a certain *screw*. Any system of forces acting upon a rigid body can be compounded into a *wrench* about a certain *screw*. These beautiful theorems are due to Poinsot; they are the elementary axioms from which the present memoir has been developed.

The co-ordinates by which the position of a rigid body in space is usually determined consist partly of angular, and partly of linear magnitudes. In the present method the co-ordinates are all twists. Thus the position of a rigid body in space is defined by six twists about six given screws.

The importance of such a system of co-ordinates is manifest, when compared with the method used for resolving forces. Any system of forces is resolved into six wrenches about six given screws, instead of into three forces and three couples.

In the present memoir small angles of twist only are considered. One consequence of this restriction is, that the order in which twists about different screws are communicated has no effect upon the resulting position of the body.

Whatever be the motion of a body in space, it is at any instant twisting about a certain screw, which we call the *instantaneous screw*. The angular velocity with which the angle of twist changes we call the *twist velocity*.

If a body receive a twist about the screw A, and then a twist about the screw B, the resulting position could have been produced by a twist about a third screw C.

The three screws A, B, C, lie upon the conoidal cubic surface, whose equation is

$$z(x^2 + y^2) - 2mxy = 0$$

this surface has been named the cylindroid, at the suggestion of Professor Cayley.

All the generators of the cylindroid are screws. The pitch of the generator which is inclined to the axis of x at the angle θ is

$$p + m \cos 2\theta$$

where p is an arbitrary constant.

The cylindroid is completely determined when two of its screws are given.

All cylindroids are similar surfaces, depending upon a single parameter m. Two parallel planes at a distance $2m$ include the entire surface between them.

A model of the cylindroid has been constructed. The generating lines are formed by steel wires forced into holes properly placed upon a boxwood cylinder the axis of which is the nodal line of the surface. The pitch is shown by colouring a length $m \cos 2\theta$ ($p = 0$) upon each generator. Different colours indicate the sign of the pitch whether + or −.

The fundamental property of the cylindroid is thus stated: If three screws upon the surface be taken, and if the body be twisted about each screw through a small angle proportional to the sine of the angle between the other two, the body after the last twist will occupy the same position as it did before the first.

A wrench about a screw A, and a wrench about a screw B, act upon a body. Determine the single screw C, a wrench about which shall be equivalent to the wrenches about A and B, acting together.

The screw C lies upon the cylindroid, which is determined by A and B. Three wrenches about three screws upon a cylindroid will make equilibrium (when applied to a rigid body), if each of the wrenching forces be proportional to the sine of the angle between the two remaining screws. This theorem includes ($p = 0$, $m = 0$), the ordinary law for the composition of forces, and ($p = \infty$, $m = 0$), the ordinary law for the composition of couples.

Poinsot has shown that the composition of rotations is analogous to the composition of forces, and that the composition of translations is analogous to the composition of couples. These analogies are now shown to arise from the identity of the rules for compounding twists and wrenches by the cylindroid.

It is also to be remarked that, so far as the composition of forces, couples, rotations, or translations, are concerned, the plane can only

be regarded as a degraded form of the cylindroid ($m = o$) from which the most essential feature (the distribution of pitch) has disappeared.

If a body only free to twist about a screw A be held in equilibrium by a wrench about the screw B, then conversely a body only free to twist about the screw B will be held in equilibrium by a wrench about A. This is called the theorem of the reciprocal screws.

A pair of screws in space whose pitches are p, p' are inclined at an angle θ, and the length of the common perpendicular is d. The condition that these screws be reciprocal is

$$(p + p') \cos \theta - d \sin \theta = o$$

N.B.—θ is the angle between portions of the screws that follow the direction of a right-handed screw along the common perpendicular.

Given a screw S and a point O, through O draw OP, equal to the sum of the pitches of the two reciprocal screws along S and OP, the locus of P is an unclosed surface of the fourth order, called the *pectenoid.*

The equation of the pectenoid is

$$z^2 (x^2 + y^2 + z^2) = a^2 y^2$$

All pectenoids are similar surfaces, depending upon a single parameter. The screw $S (y = o \ x = + a)$ is called the cardinal screw of the pectenoid. A perpendicular from the origin on S is a nodal line of the surface.

All plane sections of the pectenoid through the axis of x are circles; hence all the screws of given pitch which can be drawn through a given point O reciprocal to a given screw lie in a plane.

To analyse the freedom enjoyed by a rigid body we inquire about what screws in space the body can be twisted.

If the body can be twisted about K screws, it can be twisted about an infinite number of screws which are called the *co-ordinate system of freedom K.*

All the screws reciprocal to a co-ordinate system of freedom K form a co-ordinate system of freedom $6 - K$.

$K (6 - K)$ data are necessary to define a co-ordinate system of freedom K.

If, after all the screws in space have been tried, the body cannot be twisted about any screw, the body must be fixed in space. If the body can be twisted about only one screw S, the body has freedom I. Any line P in space may be a reciprocal screw to S, provided P have the proper pitch. It follows, by the principles of reciprocal screws, that when the K freedom equilibrium problem has been solved, the problem of $6 - K$ freedom is determined also. We therefore learn that when a body has five degrees of freedom the body can be twisted about any screw in space, provided that screw has the proper pitch. That pitch is to be determined as follows:—Suppose A_1, &c., A_5 be the five screws

about which the body is free to twist, there is a single screw X which is reciprocal to A_1, &c., A_5. Every screw co-ordinate with A_1, &c., A_5 must be reciprocal to X. Thus we may choose any four elements arbitrarily in a co-ordinate screw; the fifth will be determined by the condition that this screw shall be reciprocal to X. When the body has five degrees of freedom it cannot be in equilibrium unless the forces which act upon it form a wrench about X.

The cases of freedom *II.* and the reciprocal system of freedom *IV* are next discussed. If a body be capable of displacement about two screws A, B, it can be displaced about every screw upon the cylindroid determined by A, B. Thus the cylindroid expresses the freedom enjoyed by the body. A screw X in general cuts the cylindroid in three points, P, Q, R. If the screw X be perpendicular to the generator of the cylindroid through P, it will be found that the generators through Q, R have equal pitches. If now we assign to X a pitch equal in magnitude, but opposite in sign, to the pitches of the generators through Q and R, then X will be reciprocal to the cylindroid. Through any point O in space it is found that a whole cone of the second order of screws reciprocal to the cylindroid can be drawn. This cone is easily constructed, by joining the point O to the ellipse in which a certain tangent plane cuts the cylindroid. A body free to twist about the cylindroid will be in equilibrium, notwithstanding a wrench about any one of these reciprocal screws, a cone of which can be drawn through every point. The reciprocals of these theorems contain the most general solution of the problem of freedom *IV.* We learn that when a body is free to twist about four screws, a cylindroid can be uniquely determined reciprocal to these four screws; when this cylindroid has been found, the entire co-ordinate system becomes known, and a cone of the second order of co-ordinate screws can be drawn through every point. We also see that the reactions of the system can only produce a wrench about a screw of the reciprocal cylindroid, or, in other words, that a body having four degrees of freedom can only be in equilibrium when the wrench which acts upon it is about a screw on the reciprocal cylindroid. One screw co-ordinate with freedom *IV.* can be drawn through any point in space, so that its pitch shall have any given value from $+\infty$ to $-\infty$. The case of freedom *III.* is of peculiar interest, partly from the fact that the reciprocal system is of the same order, and also because the important problem of the motion of a body about a fixed point is included. In the present memoir, however, particular cases are not discussed. Three co-ordinate screws, X_1, X_2, X_3, can be drawn through any point O in space co-ordinate with three given screws A, B, C. Three screws, Y_1, Y_2, Y_3, can also be drawn through O, reciprocal to A, B, C. If a sphere be described around O as centre, the spherical triangle formed by the intersection with the sphere of X_1, X_2, X_3 is the polar of the triangle formed by the intersection of Y_1, Y_2, Y_3. A screw of given pitch p, reciprocal to the system A, B, C, must be a generator of a certain hyperboloid. The other system of generators of the hyperboloid is the locus of screws reciprocal to A, B,

C, whose pitch is $-p$. Strictly speaking, the case of freedom VI. is the reciprocal of the case where the body is immovable. In the latter case the body remains in equilibrium wherever be the screw about which a wrench acts. In the former the body can be twisted about every screw in space.

Whatever be the nature of the restraints which prescribe the liberty of a rigid body, it is possible to choose a system of K screws such that when the body is free to twist about each and all of these screws, its freedom is precisely the same as with the given restraints. [N. B.—Small movements only.]

Any K screws of the co-ordinate system may be selected to express this freedom.

It is manifest that the power of replacing a given system of restraints by another equivalent system may be useful in the solution of mechanical problems.

One screw can be found in space reciprocal to five given screws in space. This is a very important theorem.

Given a cylindroid and a screw X, one screw Y can always be found, upon the cylindroid such that X and Y are reciprocal.

Given any seven screws in space. It is possible in one way to find seven twists (or wrenches) about these screws, such that their effect upon the position (or equilibrium) of a rigid body shall completely neutralise each other.

A construction follows by which we are enabled to decompose a given twist (or wrench) about a given screw into six twists (or wrenches) about six given screws.

When a body has K degrees of freedom, the reaction of the restraints produces a wrench about a screw of the reciprocal system.

A body having K degrees of freedom is in equilibrium when acted upon by a wrench about a screw of the reciprocal system.

A body which is in equilibrium under the action of any forces receives a twist about a screw A (the *displacement screw*). A wrench commences to act about the screw X (the *restoration screw*).

The forces which hold a body in equilibrium form a conservative system. A, B are a pair of displacement screws; X, Y the corresponding restoration screws. If A be reciprocal to Y, then B is reciprocal to X. This appears to be an important property of a conservative system.

A free body is in equilibrium under a conservative system. A set of six screws, A_1, &c., A_6, can be chosen in an infinite number of ways, such that each restoration screw, (X_1, corresponding to A_1, for example), is reciprocal to the five remaining displacement screws, (A_2, &c., A_6.) The six screws are called *conjugate screws of potential energy*.

If a rigid body receive an *impulsive wrench* about a given screw, the body commences to twist about a certain *instantaneous screw*.

X and Y are a pair of impulsive screws, A and B the correspond-

ing pair of instantaneous screws. If A be reciprocal to Y, then B is reciprocal to X.

A set of six impulsive screws, X_1, &c., X_6, acting on a rigid body, can be chosen in an infinite number of ways, such that each instantaneous screw (A_1, corresponding to X_1, for example) is reciprocal to the five remaining impulsive screws (X_2, &c., X_6). The six screws, A_1, &c., A_6, are called *conjugate screws of kinetic energy.*

It can be shown that, in the case of a perfectly free body, one set of screws, A_1, &c., A_6, can be chosen, which are conjugate screws, both of kinetic and potential energy. The six screws thus defined are called *normal screws.* If a body be displaced from a position of stable equilibrium by a twist about a normal screw, the body will continue to oscillate for ever, by twisting backwards and forwards along the screw. Whatever be the initial displacement of the body, it can be resolved into six twists about the six normal screws; and whatever be the initial twist velocity, it can also be resolved into six twist velocities about the six normal screws. Whatever be the small oscillations, the movement is necessarily compounded of six twist oscillations about the six normal screws.

In general, when a body has K degrees of freedom, its small oscillations in the vicinity of a position of stable equilibrium are compounded of K twist oscillations about K normal screws.

The memoir further contains several general theorems with reference to the system of co-ordinate screws of freedom K and the reciprocal system; a development of the principle of reciprocity; an account of the geometrical properties of the cylindroid; and, finally, a detailed examination of the co-ordinate system appropriate to each degree of freedom. Figures representing models of the cylindroid and pectenoid illustrate the paper.

XXVI.—Observations on Earl Stanhope's alleged Imperfections of the Tuning-fork. By Michael Donovan, Esq.

[Read November 30th, 1871.]

The instrument called the "Tuning-fork," so well known to every musician, has long been used as the means by which the pitch of the various musical instruments used in a concert is to be determined, in order to attain perfect accordance.

That it deserves this confidence was several years since called in question by Earl Stanhope, in his "Principles of the Science of Tuning Instruments with fixed tones." The following are his words:—"There is, in practice, an objection to forks which is not generally known. It is this: out of a hundred forks, there is, perhaps, not one which has not a beating in it when it is struck. How, then, is it possible to tune an instrument accurately by means of forks which do not yield a pure or single sound?"

Whether or not the alleged imperfection of the fork may have shaken the confidence of tuners is uncertain; but it is a fact that the instrument called the "pitch-pipe" is at present much in use, although it is known that its pitch varies a little according to the strength of the blast and the temperature, while that of the fork is invariable at all ordinary temperatures.*

Earl Stanhope adduces the alleged imperfection of the fork as an argument against the efficiency of a mode of tuning piano-fortes occasionally resorted to, by means of twelve forks, each tuned to one particular tempered note of the diatonic scale. An ear capable of judging accurately of unisons was then competent to tune any instrument with twelve fixed tones, without reference to temperament.

The Earl proceeds to say: "I have contrived a tuning instrument which is far superior. It consists of thirteen slips of plate-glass, each of which is exactly six inches long by two inches in breadth. They are tuned, respectively, one perfect octave higher than the pitch of keys in the monochord table; for by varying the thickness I can tune one slip to C, another to G, &c. The thickness of the slip which yields the sound of the middle C is about nine hundredths of an inch; and the thickness of the slip which yields the sound of the first treble C is about eighteen hundredths. Those two C's are the two extremes. Each slip yields a sound which is extremely pure. . . By means of this tuning apparatus, which is pitched to my new and improved temperament, any careful person, with a moderate ear, can tune an instrument perfectly."

The necessity for having recourse to this difficultly obtainable tuning apparatus could only arise out of the alleged imperfection of the fork; and, previously to coming to any conclusion on the subject, it is proper to inquire whether that imperfection really exist. If there be a beat, it must be true that each prong is a separate musical instrument, and gives an independent ring at a different pitch from the other. In order to try if I could perceive this duality of pitch, I made the following experiment. A tuning-fork, with long prongs, being held by the shank, was smartly struck, and one of its tops instantly applied to a surface of water; there was an instantaneous momentary ring which was exactly at the pitch of the whole fork. The trial was then made with the other prong, and with precisely the same effect. If these trials prove anything, it would be that the prongs were in unison. But there may be a further inference. I conceive that if each prong had been in a state of independent vibration the contact with water of one prong would silence that one only, but both were silenced at the same moment, although the natural sound of the fork would have been audible during three or four seconds; for in order to intensify and prolong the sound, after dipping the top of the fork, the shank was

* Dr. Smith found his organ a quarter tone higher in summer than in winter. All wind instruments are much affected by the breath of the performer.

immediately pressed on the belly of a violin, the effect of which in ordinary cases is considerable and well known.

So far as the experiment goes, it shows that the two prongs act in concert; for if not, and if they sounded independently of each other, the ring of one should not have been extinguished by the dipping of the other. The same inference is more strongly suggested by the following. An invention was registered some years since for a tuning-fork furnished with a sliding weight on each of its prongs, which, by being moved up or down, both together, altered the pitch of the ring, and afforded a succession of notes of the tempered diatonic scale. The sliding weights should be relatively in the same position on the prongs. If one weight were moved a little down, the pitch was sharpened; but, if moved lower, the fork when struck would no longer give any sound; for then that prong could not vibrate, and the other *would* not, as both were not in condition to do so; proving that the prongs do not give independent vibrations, but that the instrument acts as a whole.

In support of his opinion Earl Stanhope states that "it is frequently practicable to get rid of the beating in a tuning-fork by very carefully filing the two prongs so as to make them exactly alike throughout." Doubting the necessity, as well as the alleged efficacy, of filing, I tuned a piano-forte string precisely to a fork which gave the note C, and filed off about a quarter of an inch from the length of one of the prongs, thus creating a dissimilarity which could never occur to this amount in the manufacture. This should have caused a beat that could be easily appreciated by the most inattentive; the effect was, that the fork now gave a clear ring, a semitone sharper than the piano, showing, as in the former case, that it vibrated as a whole; there was no beat; thus proving that inequality could not cause the imperfection attributed to it.

The connexion between the teeth and the organ of hearing is so well known that it is common to say of any grating sound that "it sets the teeth on edge." Dr. Brewster quotes from Chladni that "two persons, who had stopped their ears, could converse with each other when they held a long stick, or a series of sticks, between their teeth. The sound could also be heard when a thread was held between the teeth by both, so as to be somewhat stretched." A French commission was appointed by the National Institute, in 1800, to examine a discovery made by Citizen Vidron, a music-master at Paris, for rendering music audible by persons deaf and dumb from their birth; it consisted in taking a steel rod between the teeth, the other end of which is placed on the musical instrument" (Nicholson's Journal, iv., 383).

The vulgar experiment of holding a steel poker to the teeth, while it is made to vibrate by a stroke, suggested to me the probability that by holding the tuning-fork to my teeth, the sound would be so much intensified that a beat in its ring, if it exist, might be perceptible, although not discoverable under ordinary circumstances.

On making the trial to different teeth, I found that the fork

applied to the upper teeth caused a loud ringing, and by far the loudest when applied to the canine tooth of the right side. After many ineffectual trials, I found that by allowing the vibrating fork to continue in contact with this tooth during the continuance of its vibration, and concentrating my whole attention on the result, I could perceive a feeble beating as the ringing declined. By many repetitions my ear became better educated for perceiving the effect; and after any violent exercise, as by running up and down stairs, the beating became a little more decided. So feeble was it at all times that it was with great difficulty I could fix my attention to perceive it at all.

I tried several forks with the same results: so far they agreed with the statement of Earl Stanhope. But I soon observed that the intervals of time between the beats produced in the different forks were all exactly equal—a strange coincidence: for the fact implied that all the forks had been finished by the manufacturer to the exact same degree of inaccuracy. And what was more surprising was, that the fork, from which one quarter of an inch had been filed off gave exactly the same rhythm of beats as all the others.

At this time I recollected that in tuning a violoncello, the instrument in proper position between the calves of both legs, and the interval between the third and fourth strings being more than a fifth, if the bow were evenly drawn across both strings, while at the same time the fourth string was very slowly screwed up, the confused sound of the impure fifth will gradually resolve itself into distinct beats, the intervals between which will become longer as the discord approaches a fifth; and when a perfect fifth is attained, the fact is announced by a cessation of the beatings and the coalescence of the two sounds into a burst of perfect concord which no musician can ignore. The beatings, as they occur, will give an appulse to the calf of the right leg, which, if the player be attentive, he will *feel*, and by the cessation of the appulses, he will be advertised that his instrument is in tune, although he have not been watching the sonorous effect of screwing up the string.

Earl Stanhope mentions a fact of the same character: he says that so small an alteration in the length of one of two strings as the $\frac{1}{180}$th part of the one-hundredth of an inch produces an audible beating, when the strings are precisely of the same thickness: "and not only the beating may be heard, but what is remarkable, it may likewise be distinctly felt. The best way to feel it is to support a small piece of steel wire, about two inches long, on the sound-board of the monochord, with one of the finger nails. If the lower end of that piece of wire be semi-spherical; if its upper end be pointed; and if that pointed end be applied to the new or tender part of the nail, then the beating will be *felt* very sensibly."

On one of these occasions, when I had exercised much with a view to perceiving the beatings of the fork more readily, I accidentally perceived that the beatings of my heart and the beatings of the fork applied to the canine tooth were synchronous. This observation

opened a new field of inquiry. The canine teeth, like all the others, contain a canal through which pass branches of the internal maxillary artery and nerve in the closest proximity. The artery receives and aids the pulsations of the heart, and the nerve transmits the sensation of it to the sensorium.

What may have been Earl Stanhope's mode of conveying to his ear the sound of his tuning-forks he has not informed us; but it is probable that, occupied as he was with investigating musical sounds, this philosophical inquirer would try every mode which could best satisfy his singularly acute perception, especially that which was capable of making the strongest impression. The effect of applying the fork to the teeth was well known. "Sound," says Dr. Thomas Young, "is not simply a vibration or undulation of the air, for there are many sounds in which the air is not concerned, as when a tuning-fork, or any other sounding body, is held between the teeth." Competent authorities have recommended that mode of using the fork while the tuner's hands are both engaged in the process. It is probable that this mode, amongst others, was tried by Earl Stanhope as capable of producing the greatest effect; and it was, perhaps, in this way he was led into the erroneous belief of the beatings of the fork, and the necessity of a new tuning instrument.

If the foregoing observations be well founded, it follows that this accomplished and philosophical nobleman was mistaken in supposing that the tuning-fork is not to be relied on as a standard for determining the concert pitch of the diatonic diapason. I have endeavoured to prove that the beatings, which he attributed to an inequality of the prongs of his fork, could not be produced by that inequality, if such existed; that filing would not be a remedy, and could only act in altering the pitch; that a beat in any fork is impossible; that the beatings which Earl Stanhope perceived were the beatings of his own heart.

The pitch to which musical instruments and voices must be tuned for a concert is a matter of much interest both to the performers and the audience. It has always been a subject of controversy between instrumentalists and vocalists; the former desiring to raise the pitch, the latter to lower it; until, at length, the interposition of legislative authority became necessary. A Royal Commission was issued a few years since in Paris, charged with seeking the means of establishing "an uniform musical diapason" throughout France; and of determining a sonorous standard which would answer as an invariable type; and of indicating means of assuring its adoption and conservation. After an extensive and laborious inquiry amongst the musicians and musical establishments of all the nations of Europe and America, the commission made its report, in February, 1859; and on this the Minister of State founded a decree that in all the musical establishments of France a normal tuning-fork shall be instituted of such pitch that the note *la* (A) shall consist of 870 double vibrations in a second.

It was on account of this decision, without reference to the number of vibrations, that I thought of inquiring whether our old fork, employed by Handel and all the great composers of that age, and long before it and since, was worthy of confidence with regard to clearness, purity, and unity of sound.

XXVII.—NOTES ON APPLIED MECHANICS. I. PARALLEL MOTION. II.—THE CONTACT OF CAMS. By ROBERT S. BALL, LL. D., M. R. I. A.

[Read Monday, December 11, 1871.]

I. PARALLEL MOTION.

Theorem.—A plane figure is moving in a plane according to any law. There are always two points in the figure, or rigidly attached to it, so that the four consecutive positions of each of these points is in the same straight line.

The motion of the figure can be produced by the rolling of a curve rigidly connected therewith upon another curve fixed in the plane. We may, in the first instance, replace each of these curves by their circles of curvature. Thus we may have the figure attached to the circle with centre B and radius R' (Fig. 1) which rolls upon the fixed circle within centre A and radius R.

A point P is turning instantaneously about O, and is thus carried to P'. If O' be the point of contact when P reaches P', and if $OAO' = \omega$, it is easy to see that

$$PP' = \omega . \ OP . \ \frac{R+R'}{R'}$$

If $O'P'$ be parallel to OP, the point originally at P will continue on the line PP' during the rotation about O', as well as during that about O. In this case we have

$$OO' . \sin\theta = R\,\omega \sin\theta = \omega . \ OP . \ \frac{R+R'}{R'} \ ;$$

or
$$OP = \frac{RR'}{R+R'} \sin\theta .$$

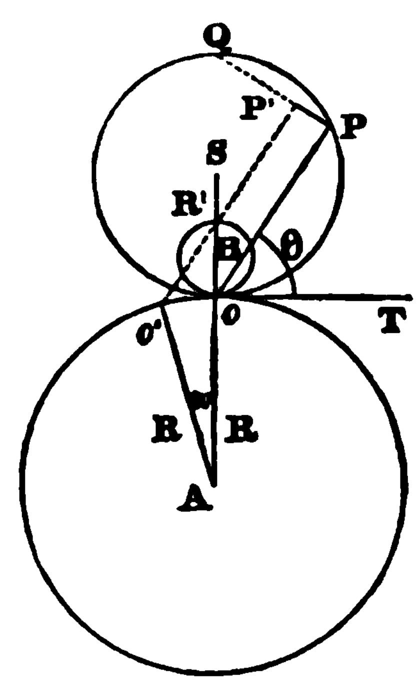


Fig. 1.

Therefore P must lie on a circle OPQ touching both the circles of curvature at their point of contact, and having a diameter equal to the harmonic mean between the diameters of the circles of curvature.

We learn from this that whatever be the motion of a plane figure in a plane, there is always a circle of points rigidly connected with the plane figure, such that three consecutive positions of each point

of the circle are in the same straight line. Further, the straight lines in which all the points of the circle move pass through the same point Q.

All the points of the circle we have found are in points of inflection upon the curves described by each point during the entire movement. Two points can however be found upon the circle at which the tangent passes through four consecutive points of the corresponding curve.

Let the circle B have rolled till O' is the point of contact, and let LXY (Fig. 2) be the new position assumed by the circle OPQ, (Fig. 1) Q having remained behind. All the points in LXY have been moving in lines passing through Q. Let O'' be the new instantaneous centre. Join $O''Q$ and upon $O''Q$ as diameter describe a circle, the points XY will still continue to move on lines through Q. Hence four consecutive positions of XY will lie upon the same straight line.

The points XY which we have determined are the points which most nearly describe straight lines. It will be seen that this general investigation includes what are known in mechanism as the parallel motions.

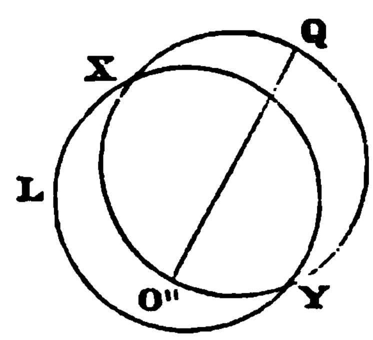


Fig. 2.

II. SLIDING CONTACT.

(*a*) Two cams in a plane, each rotating about a point, are in contact. It is required to determine, by a geometrical construction, the consecutive position of the point of contact, and also the points upon the cams which will touch at that point of contact.

The cams may be replaced by their circles of curvature at the point of contact for two consecutive positions. Let X and Y be the centres of curvature, Fig. 3, A and B the centres of motion. It is known that Z is the instantaneous centre about which the line XY turns; hence the motion of the point T is in the line TT' perpendicular to TZ; T' is therefore the next point of contact of the two cams. By describing circles $T'M$ about A, and $T'L$ about B, the points M and L upon the cams which will come into contact at T' are found.

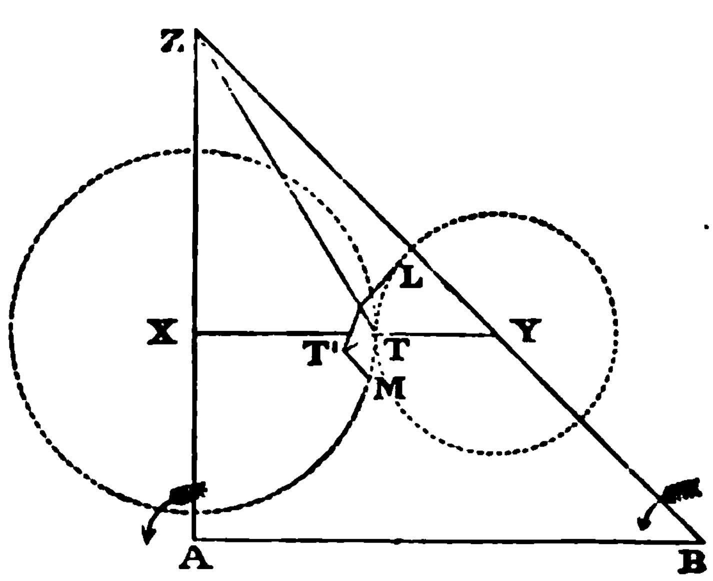


Fig. 3.

(*b*) Two cams in a plane are in contact. It is required to determine a geometrical representation for the circumstances of their mutual action.

The motion of a cam turning about a centre B (Fig. 4) relatively to the cam turning about the centre A consists of an angular velocity θ about the point N, and a velocity of translation V in the direction of the arrow marked V; these movements compounded with the angular velocity ω of A must give the actual angular velocity ω' of the cam about B.

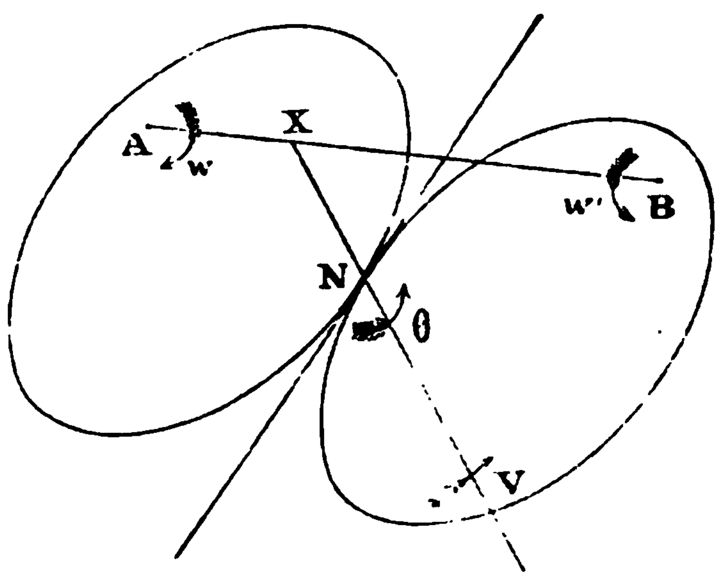


Fig. 4.

The relative angular velocity θ about N, and the velocity of translation V, compound into a single angular velocity about the point X: where XN is the normal to the surfaces of contact the angular velocity ω about A and θ about X must compound into ω' about B, therefore X must lie on the line AB, and by the laws for the composition of rotations about parallel axes which are identical with the laws for the composition of parallel forces, we have

$$\theta = \omega + \omega'$$

$$\omega : \omega' :: BX : AX.$$

$$V = XN\theta = XN(\omega + \omega').$$

We thus deduce the following theorems, the first three of which are well known, though the usual proofs do not appear so simple as those now given.

The angular velocities of two cams are in the inverse ratio of the segments in which the normal at the point of contact divides the line joining the centres.

For the motion to consist entirely of rolling, the point of contact must lie in the line joining the centres.

The velocity parallel to the tangent of the motion with which one cam slides upon the other, is found by multiplying the sum of the angular velocities by the intercept on the normal between the point of contact and the line joining the centres.

The motion of each cam relative to the other consists of a rotation about the point in which the normal cuts the line of centres.

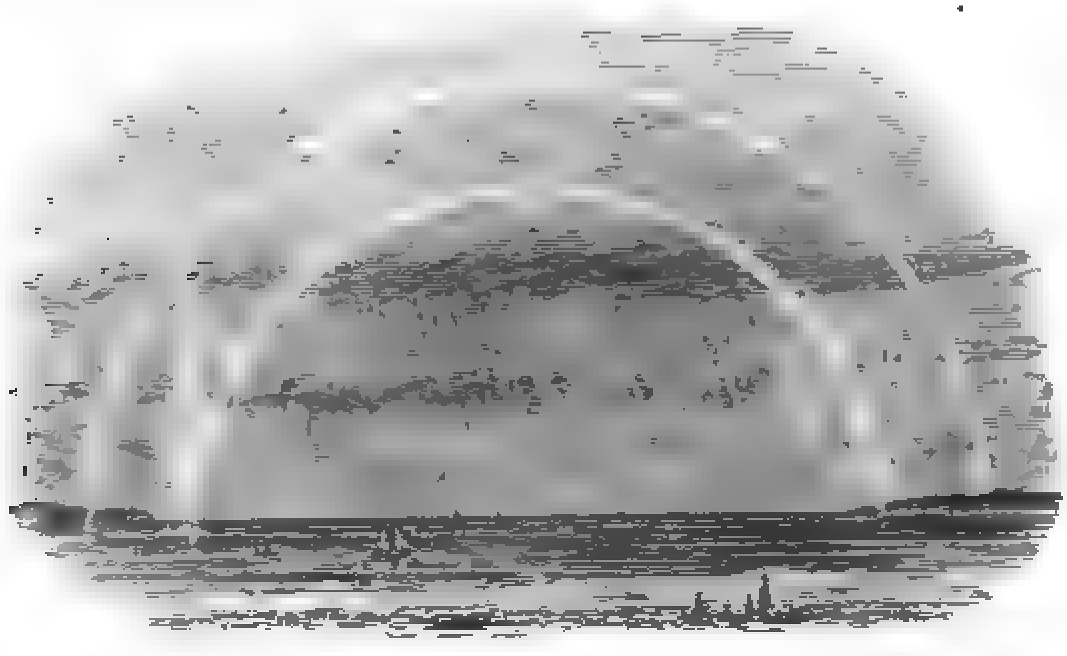
XXVIII.—Notes of Observations of Phenomena in Optical Meteorology. By Henry Hennessy, F. R. S., V. P. R. I. A.

[Read January 8, 1872.]

In the "Athenæum" for March, 1866, I described a solar halo, which was accompanied by meteorological phenomena of a remarkable kind. I now present brief notes of similar optical appearances more recently observed, partly because of the comparative rarity of one or two, but chiefly on account of their probable connexion and dependence upon more important phenomena.

On November 20th, 1869, at 10 P. M., I observed a lunar halo of 45° in diameter. It continued visible until midnight. At the time, the air was changing from a dry, cold condition to one of dampness and higher temperature. The barometer fell nearly one inch between the 21st and 22nd of November, and it is apparent that the halo was due to snow crystals which were forming in the upper cold strata of air, by the condensation of the vapour transferred thither by a current blowing from the S. W.

During the afternoon of July 10th, 1871, there were many heavy showers, accompanied by thunder and lightning, in the Bay of Dublin. Immediately after one of these showers, at 7 P. M., I observed, from Merrion, a well-developed double rainbow stretching from Howth to Killiney. Before the secondary bow had become distinctly visible, I noticed a perfectly straight vertical column of light nearly tangent to the primary bow at its north side, as delineated in the accompanying sketch.



It presented faint prismatic colours, in the same order as the rainbow—namely, violet inside and red outside—and its straightness

was easily verified by sighting it from a window. It lasted only for a few minutes, and when it disappeared I noticed a reflection of the rainbow on the water. On this account we might be led to think that the luminous vertical column was due to the refraction and dispersion of light reflected from the top of the waves. This does not perfectly explain the position of the column as tangent to the bow. As the reflecting surface furnished by the water was more unbroken and wider at this side, the tangential beam of light might be due to reflexion of the lower nearly straight and extremely brilliant limb of the bow. All through the primary bow was remarkably brilliant, which was due, no doubt, to the largeness of the rain drops falling during the thunder showers.

November 21st, about 10 P. M., the sky cleared after rain and high wind, and the air had become calm. A thin film of cloud covered the moon's disc, which was nine days old. A small corona (about 6° in diameter probably) surrounded the disc, exhibiting brilliant prismatic colours, while outside this was another corona, much paler, and not complete.

December 9th, at 2·30 P. M., I noticed a halo around the sun. By rough estimation, it appeared to have a radius of about 40°, which would bring it into a class of halos not most commonly observed. It was very sharply defined with faint prismatic colours. At one time it appeared, for a very brief interval, to have three points of maximum brightness—namely, at two points on the horizontal diameter, and at the point vertically over the sun. It disappeared about three o'clock, when the sky became covered with many light scattered clouds.

The mountains forming the background were covered with fresh snow, some of which had fallen during the preceding day or night, and the thin film of cloud in which the halo was visible was manifestly higher, and therefore composed of snow crystals, as might be expected from the established theory of halos.*

On December 19, I observed a faint and imperfect halo around the sun, at half-past two P. M.; its apparent radius much less than that of the halo just described; and it was probably about 23°, or that most usually observed. A bank of clouds was rising from the S. W., and the halo soon disappeared.

XXIX.—ON THE ACTION OF HEAT UPON SOLUTIONS OF HYDRATED SALTS. By CHARLES R. C. TICHBORNE, F.C.S., M. R. I. A. (With Pl. XIX., Science.)

[Read January 8, 1872.]

WHEN considering the dissociative action of heat upon water of hydration, some evidence was naturally sought amongst those salts which present a change of colour when passing from the dry to the hydrated

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* An elaborate discussion of the theory of halos is given in the well-known memoir by M. Bravais, Journal de l' École Polytechnique, 1847.

state. The salts experimented with were those of cobalt, copper, and nickel.

As regards such bodies, it is a general characteristic that neutral solutions of any of their chlorides do not change colour on boiling at ordinary atmospheric pressure; nor does the amount of dilution affect the tint any further than what would be due to attenuation. But in no case, where a colour change is evinced between the dry and hydrated salt, have I failed in obtaining a dehydration of it in solution by using extraordinary pressure. The laws of such a chromatic change differ from those produced by a basic condition of the salt, as will be seen further on.

Let us take, for instance, the dehydration of the salts of cobalt, which is evinced by a well-known change of colour—the conversion of the light rose colour into a dark and pure blue. The following observations conclusively prove that water of crystallization, or hydration, are easily held asunder in aqueous solutions by the dissociative influence of heat. That is to say, in a similar manner to the phenomena noticed as regards the basic and ultimate molecules in the trioxide group.*

No amount of boiling will, however, convert a pink solution of cobalt into a blue one, unless extremely concentrated. But it was observed by Prout, many years ago, that on evaporating a *strongly acid* solution of a cobalt salt to a concentrated point, he got a permanently blue solution, which, he considered, was due to the abstraction of the water of hydration by the acid. Prout also stated that he had obtained from such a solution blue crystals, supposed to be the anhydrous salt: this requires verification.

Conceiving that the cobalt salts would, from their chromatic display, be well suited to illustrate the dissociation of water of hydration by heat, I was rewarded by finding that it answered admirably for this purpose, and gave results which may be used as beautiful lecture experiments.

The thermanalytic point of the cobalt salts being above 100° C., no results, as before stated, will be obtained on boiling a neutral solution; but if any substance capable of exerting an affinity for the water of hydration be introduced, the thermanalytic point of the salt will be lowered, as shown by Prout's experiment. Sulphuric and other acids, chloride of calcium and other hygrosopic salts, and even sugar, act in a similar manner.

However, as the quantity of these dehydrants required to affect the cobalt solution was considerable, I used alcohol to lower the thermanalytic point. Chloride of cobalt, dried at 100° C., and dissolved in pure and absolute alcohol, gives a magnificent pure blue, free from the slightest tinge of purple. For this purpose it is necessary that

* Tichborne on Molecular Dissociation. Read at the Royal Irish Academy, 24th April, 1871.

the alcohol should contain no water, and it is desirable to rectify from anhydrous sulphate of copper, or chloride of calcium. The following instructive illustrations may be shown with chloride of cobalt.*

α—A blue alcoholic solution, obtained in the above manner, is placed in a deep beaker, and water is cautiously poured down the side of the vessel. Two layers will be produced, of two different colours, and will remain in this condition for some considerable time, by virtue of their different gravities. The upper layer will be blue, and contain the anhydrous salt; the lower will be pink, and contain the hydrated salt, rendered so by the direct addition of water.

β—A beaker of the alcoholic solution which has been hydrated by the addition of water is peculiarly sensitive to heat. If it is gradually heated upon a water bath, it passes, as the temperature rises, through all the shades of pink and purple, until a pure blue is produced, giving the same absorption spectrum as that obtained from the anhydrous salt. The thermanalytic point is so lowered by the alcohol present that the water of hydration of the cobalt salt is gradually but perfectly dissociated.

If we now submerge this beaker half-way into a freezing mixture, we, in a short time, obtain similar chromatic and chemical results as in the first instance; but in this case the phenomena are brought about by different means. In the beaker we have two layers, exhibiting the upper or blue one, containing the anhydrous salt, the water being present, although dissociated.

γ—It was easy to portend that, although impossible, at ordinary atmospheric pressure, and in an ordinary aqueous solution, to dissociate the water, it is only necessary to boil such a solution under a sufficient amount of pressure to obtain the thermanalytic point.

This was demonstrated by the following experiments:—A weak solution of cobalt was sealed up in a glass tube, ⅔rds of the capacity of which was empty. On boiling the liquid in this tube, the solution gradually passed through all the shades of purple, until the contents ultimately became of a pure blue. Thus, in this aqueous solution we had obtained, by extraordinary pressure, the temperature necessary for the separation of the water.

Chloride of copper† gives a beautiful blue solution in water, which is characteristic of its hydrate. It gives a brownish yellow salt in the anhydrous state; its solution in alcohol gives a greenish yellow; or, in pure æther, which has been acidulated, a brownish yellow appearance. The beautiful blue solution of the neutral salt, when heated in a sealed tube to a high temperature, becomes gradually green, yellow, and ultimately a dark brown, and nearly opaque liquid. As it cools, it gradually associates the water of hydration, and passes again through all these shades; but when cool it becomes a little opalescent, from

* The composition of the hydrated salt is $CoCl_2$, $6H_2O$, Marignac.

† $Cu\,Cl_2$, $2\,H_2O$, Graham.

the formation of a bluish white and basic precipitate. Therefore, for illustrating this experiment, it is better to use a slightly acid solution, which, from the presence of the acid, is even more sensitive to heat, and regains its original condition on cooling; hence this experiment can be performed with the same tube *ad infinitum*.

A solution of sulphate of copper, heated in sealed tubes, gives somewhat similar results as regards dehydration; but a basic salt is determined even in an acidulated solution.

The nickel salts do not, as a rule, so strikingly illustrate this phenomenon of chromatic change, although as it is well-known, the hydrated salts are green, and the anhydrous salts more or less yellow. Heated under pressure, the green chloride,* when in solution, seems to be intensified in the first instance, then becomes yellow, and ultimately a dark yellowish green. This, at first sight, would appear somewhat anomalous, but, on examination, its anhydrous alcoholic solution presents similar anomalies on cautiously adding a weaker alcohol.

It is necessary, in these experiments, that considerable caution should be used, as an explosion frequently occurs. As wire gauze would prevent the gradual change in colour from being observed, it is better to heat the experimental tube in a second glass, one considerably larger. The experimental, or hermetically sealed one, should be as small in calibre as the necessary observations will allow of. The volume of liquid necessary for proper observation will, of course, depend upon the depth of colour of the solution, and the amount of solution should have a small proportion to the capacity of the tube. Tubes for this purpose were made by taking a white glass tube of some considerable strength, and drawing it out until it has a diameter of $\frac{8}{100}$ to $\frac{4}{100}$ths of an inch. My attention was first drawn to the value of capillary tubes for experiments similar to the above from a lecture delivered by Dr. Andrews, "on the continuity of the liquid and gaseous state of matter."

A most important observation made in connexion with this investigation is the difference observed between the effects of dilution on colour-changes attending the basic condition, and on colour-changes attending dehydration. As might have been predicted on theoretical grounds, it is exactly the reverse in the latter case to what it is in the former. In a report recently read before the Academy, I pointed out that colour-changes resulting from formation of basic salts by dissociation (i. e. chromic or ferric salts) are influenced by the fact that dilution lowers the thermanalytic point. This is due to the basic action of the water itself. But it is self-evident that an increased volume of water will act differently in cases where the change of colour depends upon dehydration. In the first case the increase of volume in the water will assist the dissociation, and lower the ther-

* $Ni\,Cl_2\,9, H_2O$, Marignac.

manalytic point. In the second case, the increase in the relative volume of water retards the dissociation of water of hydration. In the second case it is inversely to the amount of dilution. Thus a solution formed of equal weights of crystals of ferric chloride and water is not greatly affected by heating to 100° C., while no solution of chloride of cobalt weaker than five per cent. is affected at the boiling point of water. The thermanalytic point may be determined approximately by taking a capillary tube containing the salt to be tried, and putting this into a second tube containing a mixture of chloride of calcium and glycerine, which will carry the temperature up to 200° C., or a pressure of about 16 atmospheres. Heat is now carefully applied, at the same time that the temperature is determined by a thermometer, which can be used to keep the whole moving. In the following Table a series of observations made with chloride of cobalt is placed in juxtaposition with one made with ferric chloride, to illustrate what has been just said:—

Dissociation attended with the formation of a Basic Precipitate Fe_2Cl_6.		*Dissociation of Water of Hydration* $CoCl_2$.	
Per centage of Crystals.	Temperature to determine Precipitation.	Per centage of Crystals.	Temperature and Colour.
50	Over 100° C. No precip.	50	60° Amethyst. 77° Purple. 100° Blue.
10	94° C.	25	85° Amethyst. 124° Purple. 135° Blue.
5	82° C.	10	180° Amethyst. 195° Purple. 227° Blue.

Plate XIX. is a graphic representation of the results contained in this Table. Two of the curves represent the dissociation of water and salt molecules in hydrated chloride of cobalt; and two curves, namely, those of ferric chloride and the ammonio-ferric alum represent dissociation attended by separation of basic compounds. The cobaltic curve marked "Amethyst" represents the temperatures at which the dissociation begins, which is shown by the pink salt changing to an amethyst colour; the second shows where the salt becomes anhydrous, which is indicated by the solution becoming blue. In decompositions of this kind dilution retards dissociation: where basic compounds are separated it is the reverse—dilution assists decomposition.

The dissociation, therefore, of the water of hydration of salts when in solution is gradual, and progresses with the increment of tempera-

ture until perfect dehydration takes place. It is evident, also, that in the salts tried perfect dissociation takes place at a higher point than the boiling point of water, when operating at ordinary pressure, and except we are dealing with very concentrated solutions. It then becomes difficult to determine how far dissociation of the more ultimate molecules may play an exceptional part in the decomposition. Lastly, we also perceive that dilution raises the thermanalytic point as regards the molecules of hydration.

XXX.—On the Floatation of Sand on the River Ganges. By Mr. F. X. J. Webber, in a communication to Henry Hennessy, F. R. S., Vice President of the Academy.

[Read 8th April, 1872.]

[In making this communication to the Academy, Professor Hennessy referred to his Paper on the Floatation of Sand by the Rising Tide in a Tidal River, read on April 10, 1871, and especially to his anticipation that tropical regions of the earth would present favourable conditions for the occurrence of similar phenomena. This anticipation was immediately verified during the discussion which followed, when Dr. E. Perceval Wright mentioned facts that came under his observation during his voyage to Mauritius and the Seychelles Islands.

The remarkable instance of sand floatation now brought under the notice of the Academy differs from those hitherto mentioned, in the circumstance that it occurred in fresh water, and its geological importance is enhanced by the magnitude of the river where it took place.]

I remember often having seen sand floating on the Ganges and its larger tributaries. On one occasion I remember plunging my hand into the water, and taking it up, coated with what I at first thought was sawdust, but found on close inspection to be sand. I had observed the thin crust floating on the surface of the river, and went to clear a space, I forget for what purpose. The banks of the river at that place were low and sandy; in fact there was no vegetation for about twenty yards inland on each side of the stream. The sand itself was too hot to be borne on the *back* of the hand.

The presence of the sand on the water was, I think, owing to undermining of the banks of the river (a process, as you are well aware, continually going on in all the large rivers of India), the falling portions sometimes striking the water with considerable force, at other times sinking so gently into the river as not even to cause a splash or a ripple. It was, of course, a very hot day, with scarcely a breeze; I need not say there wasn't a cloud in the sky.

The sand appeared to form a thin crust on the surface of the river; I do not remember remarking pebbles or shells in it.

I am positive there was no decayed vegetable floating on the river,

for if there was I would not have been puzzled to account for the presence of the sand.

This particular instance I remember very well, on account of certain incidents that happened the same day, which I have never forgotten. However, to see sand floating is a very common thing in India.

[It seems from Mr. Webber's account that the sand, instead of being uplifted by the water, as in the case I observed, was gently detached by the current of the Ganges, and floated whenever its fall was not sufficient to enable its particles to penetrate through the surface of the river. I have floated needles and particles of sand by allowing them to drop from a small height on a vessel of water.]

XXXI.—ON THE REDUCTION OF DAILY WEATHER REPORTS.—By G. JOHNSTONE STONEY, M. A., F. R. S., &c.

[Read May 13, 1872.]

THE Meteorological Office has lately begun to issue daily weather reports to the public at a nominal price. The observations are taken every morning at 8 o'clock at thirty-eight stations which are in telegraphic communication with the central office in London. Three of these stations are in Norway, one in Denmark, one in Hanover, one in Holland, one in Belgium, eight in France, one in Spain, and the rest are distributed round the coasts of the British Isles, from the Orkneys in the North to the Scilly Isles in the South, and from Yarmouth in the East to Valentia in the West. The observations taken at these widely-spread stations in the morning are forwarded to London by telegraph early in the forenoon, are reduced, tabulated, and mapped during the day at the Meteorological Office, are printed off in the afternoon, posted in the evening, and are delivered at our houses the following morning by the English post. The information thus reaches the public so soon, that it is still of interest in its relation to the existing weather. In fact a person who consults these reports, and who superadds to them the very roughest observation of the pressure, temperature, and direction of the wind at his own locality—just good enough to tell whether the waves of pressure, temperature, &c., are still advancing in the same direction from the day before, or have begun to retreat—such a person has better materials for forming a judicious forecast as to weather, than are within the reach of the most laborious meteorologist who spends great time, thought, and trouble in making frequent and careful observations at his own station, but who has not the prompt information which these weather reports give as to the state of affairs elsewhere.

These daily weather reports are so promptly circulated, so accessible, and of so much use to every one who is interested in the weather

that it may be expected that a very large number of persons will soon make a daily practice of consulting them, and that in this way a knowledge of some of the main facts of meteorology in a correct form and on a large scale will become familiar to many minds. And when we recollect the small number and the peculiar tastes of the persons who have hitherto addicted themselves to meteorological pursuits, I think we may reasonably expect, and expect with some confidence, a marked increase in our knowledge of the science as a result of such an increased area of mind as is now being brought acquainted with the subject.

I think, then, that any suggestion which should have the effect of clearing the information daily given in these reports from unnecessary complication, and which should bring into prominence their connexion wiih the passing phase of the weather, would do us the double service of rendering the reports more useful as materials from which forecasts can be made, and of inducing a larger number of persons to make a practice of consulting them, so as to sow the seed of future meteorological discoveries in a greater number of minds. The hope of these advantages has induced me to submit the following suggestion to the judgment of the Academy.

The suggestion which I have to offer is a change in reducing the observations, which would affect all the meteorological elements, but it would produce its most conspicuous effect, and at the same time an effect which could be easily dealt with, upon the records of temperature. I will therefore speak first of temperature, and afterwards seek to show that the same mode of treatment may, with advantage, be applied to the pressure, the rainfall, and even to the wind and the state of the sky.

Each of the daily reports is accompanied by four charts, of which one is intended to present to the eye the general state of affairs as regards temperature at 8 o'clock in the morning throughout the area of observation. Eight o'clock in the morning was no doubt selected because it is known to meteorologists that the temperature and pressure at that hour are very nearly identical with the average of the values of these elements throughout the whole twenty-four hours. The temperature charts may accordingly be regarded as exhibiting to the eye the average temperature for the day of observation. The temperatures at several of the stations are plotted down upon the map, and isothermal lines are drawn in conformity with them.

Let us then consider what it is that determines the positions of these isothermal lines upon any particular day. They in the first place depend upon the latitude, since *cæteris paribus* they would be lines parallel to the equator, representing temperatures becoming lower and lower in passing from the torrid zone towards the pole. In the next place, they undergo an annual change of position depending upon the season, travelling towards the pole in summer, towards the equator in winter. In the third place, they are affected by the locality, crowding together near the seacoast in summer and winter, moving asunder in

the intermediate seasons, and in other directions at various seasons, owing to the proximity of mountains, height above the sea, and other local peculiarities. And in the fourth place they depend on the passing phase of weather.

A similar complication of causes affects the records of the barometer, but there is this material difference between the cases of the thermometer and of the barometer:—The passing phase of weather is the cause which most affects the barometer, and the other operative causes* produce effects which are relatively small; whereas in the case of the thermometer, the passing phase of weather produces an effect which is so disguised as to be almost hidden under the much larger effects of the other three causes enumerated above.

My proposition is, then, to remove by one simple reduction the portion of the result due to all the other causes, and to tabulate and exhibit in the chart that residual portion alone which is intimately dependent on the character of the passing phase of weather. This could be effected after first forming the annual curve of temperature for each of the stations in telegraphic communication with the Meteorological Office. The materials for doing this, I believe, exist at the Meteorological Office, from the accumulation of daily records of past years. This curve for each station will tell what the average temperature at that station is on any specified day of the year, and the difference between this and the observed temperature sent to the Meteorological Office by telegraph will tell how much warmer or colder than the average the day is at that station. It is these excesses and defects of temperature which I propose should be represented on the map.

The curves to which the proposed records would give rise would doubtless be found to have as intimate a connexion with the direction of the wind as the curves of equal pressure have. During the recent extensive but feeble cyclone, the centre of which passed over the British Isles on the 4th of this month (May 4, 1872), the curves of equal pressure have, as usually happens in cyclones, been nearly coincident with the direction of the wind. But the directions of the isothermal lines have had no obvious relationship with the cyclone. And in fact the crude information given in the words "somewhat warmer," "somewhat colder," and so on, which are also entered on the maps, throws more light upon the phenomena of the cyclone than the isothermal lines do. Whereas if the simple reduction I have pointed out were applied, and the differences of the temperature from its mean amounts on the successive days tabulated and mapped, we should certainly become possessed of a fresh body of useful information. The lines of the new chart would probably be found arranged somewhat in radial lines.

* Except height above the sea, from the effect of which barometric records are always freed.

Templeton, Wade, Drummond, Mackay, &c., and in our own day by other resident as well as travelling botanists, it cannot be expected that many flowering plants remain to be added to the Flora. It is rather in the regular and systematic survey of the country, in the more exact and critical discrimination of species, and in the study of the introduced plants that advance may be looked for. That the last few years have not been altogether barren of results will be evident when we come to recapitulate the various *addenda*.

For the long list of new plants and new localities which I now have the pleasure to lay before the Academy, we are in great measure indebted to the diligence and kindness of the numerous friends who have continued to entrust us with the result of their observations; and we are glad to think that among them are some whose attention and interest were perhaps first awakened, or at least directed to a profitable end, by the use of our Cybele Hibernica.

Foremost among those to whom we are thus indebted are:—

Mr. R. Clayton Browne, jun., of Browne's Hill, who has contributed a number of localities from the County of Carlow, etc., and has thus filled up many of the *desiderata* in district iii. He is also the first botanist who has noticed *Crepis setosa* in Ireland.

The Rev. T. Allin, of Avoncore, has devoted much time and attention to the plants of Cork, and even in that well examined district has discovered many new localities, and some plants previously unknown in the county. Among them, *Rumex maritimus* and *Mentha sylvestris* deserve especial mention.

Mr. S. A. Stewart, of Belfast, has continued his diligent and careful observations, and besides numerous new stations, has found *Valerianella carinata* and *Acorus Calamus* in the North of Ireland: and *Sclerochloa procumbens* (one of the rarest Irish plants) in the very town of Belfast.

Mr. H. C. Hart has sent us some valuable notes of his many botanical rambles in Donegal, and he has also placed at our service a very full catalogue of the plants of the Southern Isles of Aran, the most complete that we have seen. He has also found *Brassica adpressa* for the first time in Ireland, and rediscovered *Alyssum calycinum* at Portmarnock.

Mr. J. Morrison, of Spring-hill, Enniscorthy, has kindly allowed us to examine his Herbarium, in which we have found, together with many other interesting plants, Irish specimens of *Oxalis stricta*, *Geranium nodosum*, *Erythræa pulchella*, and *Cochlearia anglica*.

Mr. R. M. Barrington, of Fassaroe, has supplied many localities from Wicklow and Waterford, and we are indebted to him for ascertaining that *Cuscuta trifolii* is permanently established as a colonist in the clover fields about Fassaroe.

Mr. Dowd, of the College Botanic Garden, has largely contributed towards filling up the list of district vii., and has found, for the first time in Ireland, *Malva borealis*, *Berteroa incana* and *Centaurea paniculata*. He also, with Professor E. P. Wright, has been the first to

ascertain the immense and surprising abundance of *Sisyrhynchium Bermudiana* over the low meadows lying between Woodford and Lough Derg, in some of which it actually constitutes a large proportion of the hay crop. Our reasons for still continuing to doubt the nativity of this plant in Ireland will be found fully given in the latter portion of this Paper. It will suffice here to say that a plant which has quite recently become established, with every appearance of a native, in Queensland, Australia, and also near Christchurch, in the South of England, may in Ireland have had a similar origin, and therefore cannot any longer be cited with confidence as indicating a former connexion between the American and Irish Floras.

From the Rev. S. A. Brenan, the Rev. S. Madden, Mr. John Douglas, Miss E. M. Farmer and others, we have received continual and most useful contributions. Besides these sources of private information, we have freely drawn upon Seemann's, now Trimen's, "Journal of Botany," and availed ourselves of the information given by Dr. Sigerson, Dr. E. P. Wright, Mr. S. A. Stewart, Mr. R. Tate, Mr. W. Andrews, Mr. G. H. Kinahan, and the late Mr. F. J. Foot in their published papers, the titles of which will be fully quoted hereafter.

In a copy of Threlkeld's "Synopsis Stirpium Hibernicarum," belonging to the Royal Irish Academy, are a few MS. notes left by some former owner, from which we have extracted those that seemed sufficiently important. One of these memoranda supplies a probable clue to the author of the list of plants in Harris's "Down," whose name appears to have been Isaac Butler.*

Last, but not least, we gratefully acknowledge the kindness of Dr. R. Templeton, Deputy Inspector-General of Hospitals, who has most liberally favoured us with the loan of the MS. "Catalogue of the Native Plants of Ireland," which was drawn up between 1794 and 1810 by his father, the eminent naturalist, John Templeton of Belfast.

In enumerating the plants added to the Irish Flora since 1866, it will be convenient to arrange them under the following heads:—

SUMMARY OF ADDITIONS.

Undoubted natives, 8.

Trifolium subterraneum, E.	Salix Grahami, N. W.
Trifolium glomeratum, E.	*Draba rupestris, N. W.*
Scirpus parvulus, E.	*Galium cruciatum, N. E.*
Aira uliginosa, W.	*Pyrola rotundifolia, Midl.*

Of these the last three, printed in italics, have before now been recorded as Irish, though in 1866 we did not think that there was sufficient authority for their admission as such.

All eight are well known to occur in Great Britain, but at the time when first found in Ireland neither *Scirpus parvulus* nor *Aira uliginosa* had been gathered for many years.

* A Botanist, and maker of Astrological Almanacks, who died in 1756.

Two of the eight are Western and Alpine, thus showing that something may yet remain to be done in the mountain botany of this country.

Four are Eastern, three of them having been found on the coast of Wicklow, within a short journey from Dublin. Of these, *Trifolium glomeratum* is the only species of our present *addenda* which belongs to Watson's Germanic or South-eastern type.

Draba rupestris is given in the seventh edition of Withering's "Botanical Arrangement," as found plentifully in Leitrim and Sligo by Mr. E. Murphy; but as *Draba incana* was not recorded by Mr. Murphy, though it is abundant on these mountains, while *D. rupestris* is very scarce, there is reason to fear a mistake was made in the name.

Galium cruciatum, long ago recorded in Harris's "Ancient and Modern state of the County of Down," as occurring near the Cathedral at Downpatrick, had quite escaped our notice, as it had that of Mackay; but having ascertained that it still grows in this locality, and has recently been found at Colebrooke, Fermanagh, we are very glad to restore it to its proper place in the Flora.

Pyrola rotundifolia was included in How's "Phytologia Britannica" so long ago as 1650, as having been found by Mr. Heaton in a bog by Roscrea, in the King's County, a locality not yet verified, but which may prove correct, though in all other instances, except at Multyfarnham, we have satisfied ourselves that either *P. media* or *P. minor* have been gathered in the alleged Irish localities for *P. rotundifolia*.

Natives, but doubtful as species 3.

Thalictrum Kochii Epilobium tetragonum (verum.)
Potamogeton Lonchites.

The first two are critical plants, and would no doubt be classed as varieties by a great many botanists. *Potamogeton Lonchites* (Tuck) is a new name applied by Dr. Boswell Syme to the *Potamogeton* from the River Boyne, which we referred doubtfully to *P. heterophyllus*; and if correctly identified with the American species, this is one more American plant occurring in Ireland, though found nowhere else in Europe: but it is difficult to feel quite sure, when dealing with a genus of plants so variable and so little understood as the *Potamogetones*.

Plants probably introduced, 3.

Erysimum cheiranthoides. Mentha sylvestris.
Tamus communis.

The first two have already been admitted in the works of Mackay and others; but we now for the first time are able to give satisfactory localities. It is surmised that *Tamus communis* was planted at Hazlewood by the late Mr. Wynne.

Plants certainly introduced,

But well established in the wild state, 3:—

Acorus Calamus. Hippophae rhamnoides.
Cuscuta Trifolii ("Colonist.")

the first two having been planted, the last accidentally sown when mixed with agricultural seeds. Though planted at Courtown, it is barely possible that *Hippophae* may be native on the sandhills further south, according to what we hear from Mr. J. Morrison.

Casuals.

That is, plants certainly introduced by man, and which cannot be considered permanent additions to the Flora, being waifs and strays from cultivation, or weeds springing from seeds conveyed by accident, 14:—

Cardamine impatiens. Valerianella carinata.
Brassica adpressa. Crepis setosa.
Berteroa incana. Centaurea paniculata.
Malva borealis. Carduus setosus.
Geranium nodosum. Campanula rapunculoides.
G. phæum. Mentha Requienii.
Oxalis stricta. Cynosurus echinatus.

Nearly all these are, no doubt, recent introductions, and most of them will probably disappear in the course of a few seasons. *Valerianella carinata* and *Crepis setosa* may possibly establish their hold on the ground, and thus in time become entitled to rank as "Colonists."

Thus there are thirty-one plants, which, after deducting casuals and a few that have before been borne on the Irish list, will leave at least twelve species to be reckoned as genuine additions to the Flora; and this I think is no inconsiderable result, and far exceeds the additions made to the English and Scottish Floras within the same time. Still, this scarcely increases the total number, as we have on the other hand to deduct ten plants, viz.:

SPECIES TO BE REMOVED FROM THE LIST.

?Brassica oleracea. Not a native, and nowhere well established.
Genista tinctoria. Not to be found at Killiney, some error?
?Chrysosplenium alternifolium. Thought to have been planted near Belfast, and we fear that the other stations are erroneous.
Campanula latifolia. *C. Trachelium* mistaken for it.
?Arctium majus. Name doubtful, as the only specimen is imperfect.
Calamintha Nepeta. Was *C. officinalis*.
Chenopodium intermedium. Now thought to have been *C. murale*.
Salix procumbens. Was *S. phylicifolia*.
Potamogeton lanceolatus. Was a form of *P. polygonifolius*.
Eriophorum alpinum. Some error, or change of specimens.

Among the discoveries of localities for scarce plants not new to the Flora, we have:

Neotinea intacta. Found by D. Moore on the shores of Lough Corrib in Mayo, associated with *Ophrys apifera, Potentilla fruticosa,* and other species characteristic of the Burren District, and therefore leading us to expect the discovery of this rare little orchid in other localities intermediate between Cong and Castle Taylor.

Rumex maritimus. Found by the Rev. T. Allin in Cork, this being the second Irish locality.

Arundo Epigejos. Gathered by Mr. H. C. Hart in Great Aran Island, this making the third locality in Ireland.

Diotis maritima. Found at Carnsore Point, Wexford, by Mr. J. Waddy. A new station for one of the scarcest British plants.

Equisetum trachyodon (*Mackaii* Newm.) at Blarney, and

Callitriche autumnalis at Killarney, both unexpectedly found to range to the South of Ireland.

Eriophorum latifolium at Roundstone. Range of a very local species extended to the West of Ireland.

Helminthia echioides. Range extended northwards to Antrim, and another instance of a local southern species occurring in north-east Ireland.

Adiantum Capillus-veneris. Limerick, Mayo, and Donegal added to the few counties in which this very local Fern has been found.

Poa compressa. Ballycastle and Portadown, two new districts for a very scarce grass.

Sclerochloa procumbens, Belfast, previously collected at Cork only.

Galium uliginosum, Erythræa pulchella, Carex axillaris. New localities for three scarce plants, of which we had previously seen no Irish specimens.

The extension and increase of alien weeds is illustrated by the spread of—

Anacharis Alsinastrum.	Diplotaxis muralis.
Veronica Buxbaumii.	Melilotus officinalis.
V. peregrina.	Rumex pulcher.
Crepis taraxacifolia.	Sisymbrium Irio.

To these we may perhaps add:

Sisyrhynchium Bermudiana.	Orobanche minor.
Cuscuta Trifolii.	Valerianella carinata.

While as examples of decrease we have:

Carex Buxbaumii.	Eriophorum latifolium.
C. paradoxa.	Euphorbia Peplis.
Lathyrus palustris.	Trichomanes radicans.
Arundo stricta.	Erica ciliaris.

Some of these have suffered from drainage and the reclamation of bogs, and through the recent operations of lowering the level of several of the large lakes. *Euphorbia Peplis,* from inroads of the sea or changes

in the beach, while the decrease of *Trichomanes* alone is to be attributed to the unscrupulous depredations of plant-collecting tourists.

We now proceed to enumerate the localities in regular order, premising that whenever the word "District" is placed before a numeral, it indicates that the plant is an addition to the Flora of that province.

* *Clematis Vitalba* (Linn.) District 4. Sandhills at Courtown, Wexford, growing with *Hippophae rhamnoides*, sparingly; A. G. M.

Thalictrum alpinum (Linn.)—8. Rocks on the mountain above Kylemore Castle, Connemara; D. M.

T. minus (Linn.) *var. maritimum.*—4. Kiltennel, Wexford; Miss E. M. Farmer. Sandhills, a little north of Arklow; A. G. M.

T. minus (Linn.) *var. montanum.*—12. On Slieve Donard; S. A. Stewart. This is probably the plant mentioned in "Flora Hibernica" under the name of "*T. majus.*"

T. Kochii (Fries). District 8. Shores of Lough Conn, Mayo; A. G. M.

T. flexuosum (Bernh.) District 1. Islands in the lower Lake of Killarney; A. G. M.

Ranunculus pseudo-fluitans (Syme).—12. River Bush, and River Bann; S. A. Stewart and R. Tate. Mr. W. P. Hiern refers the plant from Chapelizod to his form "*R. penicillatus*" of Dumortier, this differing from the restricted *pseudo-fluitans* by producing floating leaves.

R. cænosus (Guss.)—4. Clohass bog, Wexford; Miss E. M. Farmer. Roundwood, Glenmalure, Lough Dan, Glen Cree, etc.; common in Wicklow; A. G. M.

R. hederaceus (Linn.) District 10. Ballyskeagh, Tyrone; Dr. Sigerson.

R. Lingua (Linn.)—2. Youghal Bay; Rev. T. Allin.—8. Lake near Letterfrack, Connemara; D. M.—10. Abounds in the lakes near Drum, Clones; J. Bain.

R. acris (Linn.) The mountain form appears to be *R. Friesianus* (Jordan), and was gathered lately on Ben Bulben, Sligo, by D. M. and W. T. Dyer, and in the Horse's Glen, Mangerton, A. G. M. The ordinary plant in Ireland is *R. tomophyllus* (Jordan.)

‡ *R. arvensis* (Linn.)—12. Formerly found by Templeton at Agnew's Hill, and at Inver, near Larne, but was considered introduced; *T. Hincks* (in Ann. Nat. Hist. 1841.)

R. parviflorus (Linn.)—2. Near Middleton and East Ferry, Cork; Rev. T. Allin.—5. In a cottage garden near Prumplestown, south of Kilkea, Kildare; J. Douglas.

Caltha palustris (Linn.) var. *Guerangerii*, Bor; District 9. In Glen Iff, north side of Ben Bulben; W. T. Dyer.

Aquilegia vulgaris (Linn.)—2. Mr. T. Allin considers it probably native in North Cork.—6. Near Kilmurry, Great Aran Island; H. C. Hart. Among gorse by the stream between Woodford and Lough Derg; M. Dowd. District 7. Plentiful over a large field at Rutland, near Swinton, King's Co.; Miss E. M. Farmer.

[*Delphinium Ajacis* (Gay). A single plant in sandy arable ground at Portmarnock, 1869; A. G. M.]

Papaver Argemone (Linn.)—2. Railway embankment at Middleton; Rev. T. Allin.—4. Plentiful on the shore near Wicklow; A. G. M. —5. On a bank near Merrion shore; Annotator in Threlkeld, R. I. A. Library.

P. hybridum (Linn.)—5. Skerries; A. G. M.

P. dubium (Linn.) var. *Lecoqui* (Lam.)—5. On sandy banks at Baldoyle, with both white and yellow sap; W. T. Dyer and A. G. M.

Meconopsis cambrica (Vig.)—3. Wilton, Kilkenny; Rev. S. Madden.—5. Only escaped or planted in this district. District 10. Ballyskeagh hill, Tyrone; Dr. Sigerson.

Glaucium luteum (Scop.) District 6. Middle Island of Aran, Galway; H. C. Hart.

Corydalis claviculata (D. C.)—4. Bray Head! and wood at Luggielaw; Templeton.

Fumaria confusa (Jord.) District 4. Near Wicklow; A. G. M.

Nasturtium palustre (D. C.)—1. Marshy ground on Ross Island, Killarney; H. C. Hart.—2. Buttevant and Kanturk, not rare in North Cork; Rev. T. Allin. District 3. Near Fenagh, Carlow; R. Clayton Browne. District 4. Frequent about Enniscorthy; J. Morrison.

Obs. Cardamine impatiens (Linn.) Dr. E. P. Wright has drawn our attention to a specimen gathered by the Rev. W. M. Hind at Shane's Castle, and preserved in the British Herbarium at Trinity College, from which it appears that Mr. Hind's record of this species in the "Phytologist" was quite correct: but our careful correspondent, Mr. S. A. Stewart, has not succeeded in discovering this plant, and thinks, from the nature of the locality, that it may have been introduced. Hence we feel compelled for the present to leave its claims to a place in the Irish Flora undecided.

**Hesperis matronalis* (Linn.)—4. Formerly plentiful and apparently wild at Rockmount, between Ferns and Enniscorthy; J. Morrison. —9. Plentiful in the woods at Rockingham, Roscommon; D. M. This perhaps deserves to be considered permanently naturalized.

Sisymbrium officinale (Scop.) District 6. Aran; E. P. Wright. District 7. Parsonstown; M. Dowd.

‡*S. Irio* (Linn.)—5. Roadsides south of Rathfarnham, Milltown, and Clonskeagh; A. G. M.

†*S. Sophia* (Linn.)—5. Sandhills by the Creek at Donabate, and on the south shore of the estuary below Drogheda; possibly introduced in all the Irish localities; A. G. M.

Alliaria officinalis (Andrz). District 7. Here and there in the woods about Parsonstown; M. Dowd. District 10. Enniskillen, Fermanagh; plentiful; S. A. Stewart.

**Erysimum cheiranthoides* (Linn.) District 7. In cultivated land and waste ground along the road for two miles between Parsonstown and Portumna, in Galway, and in the adjoining part of Tipperary; M. Dowd.

[*Brassica adpressa* (Boiss.) *Sinapis incana* (Linn). A single plant at Portmarnock, 1867; H. C. Hart.]

†*Sinapis nigra* (Linn.) 4. Frequent in waste ground about Enniscorthy; J. Morrison. 12. Cultivated fields on the Curran of Larne; D. M. District 6. In cultivated ground and by waysides about Killeany, Aran; H. C. Hart.

S. alba (Linn.) District 3. Near Carlow; J. Morrison.—6. Killeany, Aran; H. C. Hart.

‡ *Diplotaxis muralis* (D. C.) District 2. Waterford; omitted in the line of figures.

[*Alyssum calycinum* (Linn.) Rediscovered at Portmarnock by Mr. H. C. Hart in 1867, and observed growing there sparingly in two small fields, from 1868 to 1872.]

[*Berteroa incana* (D. C.) *Alyssum incanum* (Linn.) A single plant at Portmarnock, in 1869; M. Dowd.]

Draba rupestris (R. Br.) District 9. Very sparingly on the north side of Ben Bulben, 1871; D. M. and W. T. Dyer. This plant was announced as Irish by Mr. W. Andrews in 1845 (London Journal of Botany, iv.), and had been previously recorded by the late Mr. Murphy, in the seventh edition of Withering's "Botanical Arrangement," as plentiful on the limestone mountains of Leitrim and Sligo; but as no mention is there made of *D. incana*, which is frequent on Ben Bulben, it must remain doubtful whether that record was not erroneous.

D. incana (Linn.) District 8. In great luxuriance on the southern shores of Lough Mask; F. J. Foot.

Cochlearia officinalis (Linn.) District 6. Aran; Dr. E. P. Wright.

C. danica (Linn.) District 6. On a ruin near Kilmurry, Aran; H. C. Hart.

C. anglica (Linn.) District 4. In a salt marsh near Ferrycarrick Bridge, on the estuary of the Slaney! J. Morrison. District 6.? Near Limerick, leaves only; I. Carroll.—10.? At Cloghcor, on the banks of the Foyle, but not in fruit; Dr. Sigerson. The Irish plant is identical with *C. anglica* as found in the North-west of England, and differs considerably from the *var. didyma* which occurs in the South of England. Only *C. officinalis* grows on Killiney Hill.

†*Thlaspi arvense* (Linn.)—5. Near Navan and Nurney, Meath. Annot. in Threlkeld, apud R. I. A.

Lepidium Smithii (Hook.)—4. Frequent in Wicklow, near Arklow, etc.; A. G. M. Gorey, Wexford, A. G. M. Bloomfield, near Enniscorthy; Miss E. M. Farmer.—5. Mullaghcreelan Hill, Kildare, sparingly; J. Douglas.

Subularia aquatica (Linn.)—12. Shores of Lough Beg, Derry; S. A. Stewart.

‡*Senebiera didyma* (Pers.)—1. At Dingle, Kerry; A. G. M.—3. At Kilmacow, Kilkenny; T. Chandlee. On a footpath at Carlow; J. Douglas.—4. Churchyard at Bannow, Wexford; R. M. Barrington. —5. Roadside at Donnybrook; V. A. Smith. Near the Canal at Bull's

Bridge; A. G. M.—6. Plentiful at Limerick; D. M. Abundant at Gort; M. Dowd.

Crambe maritima (Linn.) District 4. On the Murrough of Wicklow; Annot. in Threlkeld, apud R. I. A. A few plants by the railway near "the Breaches;" 1868–70; H. C. Hart.—5. Railway bank near Killiney; R. M. Barrington.

Raphanus maritimus (Sm.) District 4. Ballyconigar, Wexford; J. Morrison.

†*Reseda lutea* (Linn.)—5. Sandy field by the shore near Gormanstown, Meath; A. G. M. District 6. Waste ground S. E. of Killeany, Aran; H. C. Hart.

[*R. suffruticulosa* (Linn.) Shore at Newcastle, Down; Lord Clermont.]

†*Viola odorata* (Linn.)—4. Ballycarney, and by the Slaney, etc. in Wexford, where it appears indigenous; Miss E. M. Farmer. —5. Common on hedgebanks about Kilkea, Kildare, with both white and blue flowers; J. Douglas.

V. hirta (Linn.)—5. Sandhills at Portraine, opposite Malahide; A. G. M. 6. Sloping ground above Killeany, Aran; A. G. M.

V. canina (Linn. et Fries). District 2. Near St. Ann's, Blarney, (Mr. R. Mills); Rev. T. Allin.—8. A closely tufted upright form with blunt leaves occurs on the mountain slopes above Kylemore Lake; D. M.

Viola lutea (Linn.) District 4. On the banks of the King's River near Lackan, Wicklow! H. W. D. Dunlop. District 10. In the mountainous country near Bealyborough (Bailieborough.) Annot. in Threlkeld, apud R. I. A. The plant of the sandhills at Roundstone belongs rather to *V. Curtisii*.

V. Curtisii (Forst.)—1. Sands at Inch point, Kerry; A. G. M. District 4. Balliconigar, Wexford; J. Morrison. Sandhills from Courtown, Wexford, to Arklow and northwards; A. G. M. . District 5. On the North Bull, Dublin, Baldoyle, Portmarnock, Portraine, Rush, Gormanstown to near Drogheda; A. G. M. District 6. Near Kilronan, Aran; H. C. Hart. District 8. Roundstone; A. G. M. We now include under *V. Curtisii* the sandhill Pansies of both east and west coasts.

V. tricolor (Linn.) District 7. Parsonstown; M. Dowd.

Drosera intermedia (Hayne). District 11. Near Lough-an-ure, Donegal; N. Moore, Rosses; H. C. Hart.

D. anglica (Huds.) District 2. On Bluefort Bog, Newmarket; Rev. T. Allin.

Polygala depressa (Wend.) District 10. Knockavoe and near Strabane; Dr. Sigerson.—12. Black mountain near Belfast, and bogs near Toome; S. A. Stewart.

Elatine hexandra (D. C.)—1. Lough Carra, Kerry; W. Andrews.

Silene anglica (Linn.)—1. Shepperton and at Lissard, Cork; Rev. T. Allin. District 5. Sandy fields at Portmarnock, 1869; H. C. Hart. —12. By the new road to the Ferry, Bellaghy, Derry; S. A. Stewart.

Silene inflata (Sm.) District 11. Near Mulroy Lake; H. C. Hart. Near Horn Head; N. Moore.

S. maritima (With.)—12. Abundant along the basaltic range from Portrush to Craignashoag, Derry, ranging to 1200 feet; D. M.

Lychnis vespertina (Sibth.) District 3. Browne's Hill, Carlow; R. C. Clayton Browne. District 11. Near Lough-an-ure, Donegal; H. C. Hart.

L. diurna (Sibth.)—9. About Ben Bulben, Sligo; D. M.

Sagina ciliata (Fries). District 4. On the bridge at Arklow, and near the Castle ruin at Wicklow; A. G. M.

S. subulata (Wimm.) District 11. Dunaff Head, Donegal; H. C. Hart.

Honkeneja peploides (Ehrh.) District 6. Aran; H. C. Hart.

Arenaria serpyllifolia (Linn.) District 6. Aran; H. C. Hart. District 7. Parsonstown; M. Dowd.

Arenaria ciliata (Linn.)—9. A specimen preserved in Buddle's Herbarium in the British Museum was collected by Lhwyd near Sligo, probably in 1699 (Seemann's Journal of Botany, 1870, p. 324.)

Stellaria graminea (Linn.) District 11. Glenalla, Donegal; H. C. Hart.

Obs. *Malachium aquaticum* (Fries). The specimen in Cork Institution is attributed to Drummond by Dr. Hincks (Ann. Nat. Hist. 1841), but is not included in Drummond's own list; hence we fear some mistake has occurred.

Cerastium glomeratum (Thuil.) District 11. Killybegs, etc.; H. C. Hart.

C. triviale (Link). District 7. Parsonstown; M. Dowd. District 11. Pettigo and near Lough Derg; S. A. Stewart.

C. arvense (Linn.)—5. On Feltrim Hill and at Donabate; A. G. M. Plentiful on the north side of Lambay Island; R. M. Barrington.

Malva moschata (Linn.)—3. Here and there in Carlow; R. Clayton Browne. In Queen's County; J. Douglas.—4. Near Ovoca station; A. G. M.—5. Near Drogheda; J. B. Hamilton.

[*Malva borealis* (Wallm.) Two plants were found by Mr. M. Dowd in 1869, growing on some rubbish at Donnybrook, near Dublin, evidently introduced by some accident].

Althæa officinalis (Linn.) District (11.) Near Bundoran, 1867; H. C. Hart. Probably an escape from a garden. The natural localities are very few, and careful investigation is required to determine the proper range of this plant in Ireland.

†*Lavatera arborea* (Linn.)—6. Apparently indigenous on the north cliffs of the great Island of Aran, and on Rock Island, the most western of Aran; H. C. Hart.

Hypericum dubium (Leers).—4. Roadside near Cloghamon, Wexford; J. Morrison. Near the station at Ovoca, Wicklow; A. G. M.

H. pulchrum (Linn.) District 10. Castle Derg, Tyrone; S. A. Stewart.

†*Acer campestre* (Linn.) District 9. Hedges about Sligo; D. M.

Geranium pratense (Linn.)—12. Dunluce Castle, and all the north part of Antrim; about Ballintoy; R. Templeton, M. S. On blown sand at Port Bradden; R. Tate. Mr. Tate has confirmed the accuracy of Mr. Templeton's observations, and has found *G. pratense* much more frequent than *G. sylvaticum* on the north coast.

‡*G. pyrenaicum* (Linn.) District 2. Roadside near Charleville, and a single plant in a pasture field near Middleton; Rev. T. Allin.—5. Roadside banks near the Hill of Tara, Meath; A. G. M.

G. columbinum (Linn.)—2. Near Middleton and Castletown-Roche; Rev. T. Allin.

Geranium rotundifolium (Linn.)—2. Rare about Middleton; Ballyvodock, and near Youghal; Rev. T. Allin. District 5. Rediscovered in 1867 on some old walls at Glasnevin; D. Orr.

[*G. nodosum* (Linn.) Wood at Newtownbarry, Wexford; well-established in 1871; J. Morrison.]

[*G. phæum* (Linn.) Has grown for many years in a neglected avenue near Ballybeg Railway Station, Meath; G. Dawson. At Roxboro', Middleton, remains of cultivation; Rev. T. Allin. By the roadside a mile south of the Church in Island Magee; R. Tate. In all cases introduced.]

Erodium cicutarium (Sm.) District 6. Aran: H. C. Hart.

E. moschatum (Sm.)—1. Many places in West Cork, as Leap, Glandore, Clonakilty, etc.; Rev. T. Allin.—2. Frequent on roadsides near Youghal; ditto.—4. Near Bannow, Wexford; R. M. Barrington.—6. Near Killeany and Kilronan, Aran; H. C. Hart. District 11. Roadside at Rathmullen, Donegal; Rev. T. Allin.

Erodium maritimum (Sm.)—12. Sands at Portrush; S. A. Stewart.

Linum angustifolium (Huds.)—2. Not rare near Youghal; Rev. T. Allin. Railway banks, Waterford; R. M. Barrington. District 3. Near Kilkenny; W. Archer.—4. Bannow; R. M. Barrington. Bloomfield and near Daphne; Miss E. M. Farmer.—5. A little north of Gormanstown, Meath; A. G. M. District 6. Meadows between Woodford and Lough Derg; M. Dowd.

Radiola millegrana (Sm.)—1. Berehaven; A. G. M.—2. Ballintowtas, Middleton; Rev. T. Allin.—11. Common in Fanet; H. C. Hart.

[*Oxalis stricta* (Linn.)—Belfast (G. O'Brien, 1842), Lisnagarvey, near Lisburn, 1850 (S. Pim); Herb. Morrison.]

Rhamnus catharticus (Linn.)—6. In Great and Middle Aran; H. C. Hart. District 5. Monasterevan and District 3. Cottoner's brook by Mountmellick; Annot. in Threlkeld, apud R. I. A.

R. Frangula (Linn.) District 3. Plentifully in Mountmellick bog by Cottoner's Wood, 1732; Annot. in Threlkeld, apud R. I. A.

Ulex (*nanus*) *Gallii* (Planch). Ascends above 2000 feet on Carn Tual, to 1500 or 1600 on Mangerton, thus ranging much higher in the West of Ireland than in England; A. G. M.

Genista tinctoria (Linn.) Has not been rediscovered in the only locality given by Mackay, and we much fear that a dwarf and procum-

bent state of *Sarothamnus scoparius* which grows on Killiney Hill and at Howth has been mistaken for it.

[*Medicago falcata* (Linn.) Portmarnock; *Flor. Hib.*, but not seen recently. Terminus, York street, Belfast; W. Millen. Evidently introduced. This was intentionally omitted in our book, as having no claim to be considered established.]

‡*Melilotus officinalis* (Willd.)—2. A few plants in a pasture field at Ballinacurra, 1870; Rev. T. Allin. District 4. Roadside opposite a mill on the River Urrin, near Enniscorthy; Miss E. M. Farmer.—5. On the mountain side south of Rathfarnham; Annot. in Threlkeld, apud R. I. A. Plentiful along the railway embankment north of Malahide, and here and there about the sandhills at Portraine and Rush; A. G. M. and D. M. Raheny; H. C. Hart.

**M. arvensis* (Willd.)—12. Railway embankment between Kilroot and Whitehead, and between Glynn and Larne, Antrim; R. Tate.

Trifolium arvense (Linn.)—2. Plentiful on Cable Island, Youghal; Rev. T. Allin.—4. Curacloa, Wexford; Miss E. M. Farmer.—5. Sandy ground near Merrion; *Threlkeld.* District 6. Between the Lighthouse and the old Fort in South Island of Aran; H. C. Hart.

T. striatum (Linn.)—5. Abundant on Feltrim Hill, A. G. M. On a headland north of Rush; D. Orr.

T. scabrum (Linn.) District 2. Sands at Fanisk, Youghal; Rev. T. Allin. District 4. Near Newcastle and Killoughter, Wicklow; A. G. M. Between Kilcool and Greystones; H. C. Hart.—5. Killiney; D. M. On the North Bull! and Sutton side of Howth; D. Orr. It is this species rather than *T. striatum* which has been mistaken for *T. maritimum* in Ireland.

T. glomeratum (Linn.) District 4. By the river side near the railway station at Wicklow, growing with *T. subterraneum*, 1869; D. M.

T. subterraneum (Linn.) District 4. By the river side at Wicklow, June, 1867; A. G. M.

T. ornithopodioides (Linn.)—4. On the hill near the Castle ruins at Wicklow; by the river at Wicklow; near the river at Bray; A. G. M.

T. fragiferum (Linn.)—4. Common near the sea in Wexford; Miss E. M. Farmer.—5. Shore at Ballybrack, Dublin, and at Gormanstown and Laytown, Meath; A. G. M.

T. procumbens (Linn.) District 10. Frequent in Tyrone; Dr. Sigerson.

T. filiforme (Linn.)—4. Arklow; A. G. M. District 10. At Tynan Abbey, Armagh; S. A. Stewart.

Lotus corniculatus (Linn.) *var. tenuis.* District 12. Near Glynn, Antrim (S. A. Stewart); R. Tate.

Anthyllis vulneraria (Linn.) District 10. Clogh-cor, Tyrone; Dr. Sigerson. Five-mile town; T. O. Smith.

Vicia hirsuta (Koch). District 6. Woodford, Galway; R. M. Barrington.

V. sepium (Linn.) District 7. Parsonstown; M. Dowd.

V. lathyroides (Linn.) District 11. Dunaff Head, Donegal; H. C. Hart.—12. Warren at Donaghadee, Down; S. A. Stewart.

‡*Prunus insititia* (Linn.) District 10. Artigarvan, Tyrone; Dr. Sigerson.

†*P. avium* (Linn.) District 10. Lower Holy Hill, Tyrone; Dr. Sigerson.

Poterium Sanguisorba (Linn.) District 4. About Fassaroe, near Bray, in several places; R. M. Barrington.

Agrimonia Eupatorium (Linn.) District 11. Fanet, Mulroy, etc., in Donegal; S. A. Stewart. Carrigart; H. C. Hart.

A. odorata (Mill.) District 4. Near Enniskerry; A. G. M. District 8. Very fine near Clifden, Connemara; never seen by me on the limestone, where *A. Eupatorium* seems to take its place; A. G. M.

Potentilla fruticosa (Linn.) District 9. On the north-east shore of Lough Corrib; D. M.

Rubus idæus (Linn.) District 10. Plentiful in Fermanagh and Tyrone; S. A. Stewart.

R. cæsius (Linn.) District 7. Near Parsonstown; M. Dowd.

Geum rivale (Linn.) Districts 3, 4, 6, 7, 8, 9, 10, 11, 12, which were accidentally omitted.

‡*Pyrus Malus* (Linn.) District 10. Glenmornan and Artigarvan, Tyrone; Dr. Sigerson. District 11. One tree in the Rosses, Donegal; H. C. Hart.

P. Aucuparia (Gaert.) District 10. Glenmornan, Tyrone; Dr. Sigerson.

‡*Epilobium roseum* (Schreb.)—12. First found by Mr. Templeton in his orchard at Cranmore in 1820, but apparently occurs only as a weed or colonist in this district.

E. hirsutum (Linn.) District 10. By Lough Erne near Tempo; T. O. Smith.

Epilobium tetragonum (Linn.) (typical.) District 5. By the roadside west of Carrickmines! Prof. A. Dickson. This is the only locality at present known to us.

E. palustre (Linn.) District 7. Common near Parsonstown; M. Dowd.

Myriophyllum verticillatum (Linn.)—6. Ditch near the bridge at Portumna: S. A. Stewart.

M. alterniflorum (D. C.) District 2. Plentiful in this district, about Middleton, etc.; Rev. T. Allin. District 10. Castle Derg, Tyrone; S. A. Stewart. District 12. Lough Neagh, Glenarm, etc.; R. Tate.

Lepigonum rubrum (Fries). District 4. Strand at Ballyconigar! Wexford; J. Morrison. On Vinegar Hill! H. Robinson.—12. South-east shore of Lough Beg, near Toome; S. A. Stewart. This seems quite rare in Ireland.

L. rupicola (Lebel).—4. Near Arklow and Wicklow; A. G. M. —5. Sandhills north of Rush, a most unusual kind of station; A. G. M. District 8. On many of the Islands off Connemara; A. G. M.

Scleranthus annuus (Linn.) District 11. Roadside between Croaghross and Rossnakill; H. C. Hart.

Sedum Telephium (Linn.)—6. Roadside between Woodford and Lough Derg; M. Dowd.—12. Galgorm, Ballymena; (*S. Fabaria.*) R. Tate.

**Sedum dasyphyllum* (Linn.)—2. At Carrickshean, near Middleton, where it covers a range of limestone hills and appears quite wild; Rev. T. Allin. District 12. On rocks in Glenariff Glen, Antrim, growing with *S. reflexum*; R. Tate.

Sedum anglicum (Huds.) District 3. Scalp rocks between Fenagh and Bagnalstown, Carlow; R. Clayton Browne.

Cotyledon Umbilicus (Linn.) District 10. Castle Derg, Tyrone; S. A. Stewart. Near Strabane; Dr. Sigerson.

Saxifraga umbrosa (Linn.)—11. In "the Poisoned Glen," and on a mountain south of Lough Ea, Donegal; N. Moore.

S. Geum (Linn.) District 2. Rocks above Gurthaveha Lake, near Millstreet; A. G. M.

S. Hirculus (Linn.) District 3. Bogs near Mountrath, Queen's County; J. Morrison.

S. aizoides (Linn.) District 11. In a gully on the north side of Slieve League, Donegal! H. W. D. Dunlop.

S. hypnoides (Linn.) In the Journal of Botany, vol. viii., p. 280, (1870), Mr. J. G. Baker has re-arranged the forms of this variable plant under five varieties, all of which occur in Ireland.

1.? *Cæspitosa* (Linn.) An imperfect specimen gathered on Brandon Mountain by Mr. Wilson, in 1829, is the only evidence of the occurring of this form in Ireland.

2. *Sternbergii* (Willd.) Brandon Mountain, Macgillicuddy's Reeks, and Galtymore. This is the *S. hirta* of Smith.

3. *decipiens* (Ehrh.) Sleeve Neesh, near Tralee; J. G. B.

4. *quinquefida* (Haw.) Top of Brandon Mountain and Isle of Aran in Galway Bay; J. G. B. This is *S. affinis* (D. Don), and is said to be more common in Wales and Scotland.

5. *hypnoides* (Linn.) Hills in Sligo; J. G. B.; and probably frequent on the calcareous districts of the West of Ireland.

S. hypnoides (Linn.) District 11. The Little Bins, Ballyvicstocker Bay, Donegal; H. C. Hart.

S. granulata (Linn.) District 4. On the sandhills south of Mizen Head, Wicklow; D. M. Brittas, 1866; J. Morrison. District 10. On the mound at Raththrillick, Armagh; S. A. Stewart.—12. Plentiful in Belvoir Park; Belfast. Nat. Field Club Report, 1871.

Cicuta virosa (Linn.)—9. Plentiful in Lough Bofin, Leitrim; W. T. Dyer.—10. In Cavan and Fermanagh; Annot. in Threlkeld, apud R. I. A. Sparingly at Dartry, Monaghan; M. Dowd.

Apium graveolens (Linn.) District 6. In Great Aran Island; Dr. E. P. Wright (but only seen here near cottages; H. C. Hart.) District 12. Near Belfast, etc.; Flor. Ulst. and Flor. Belfast.

‡*Ægopodium Podagraria* (Linn.)—4. Clonass and Verona, Wexford. Miss E. M. Farmer.

Carum verticillatum (Koch).—1. Plentiful a little north of Kenmare; A. G. M.

Pimpinella magna (Linn.)—2. Abundant near Buttevant, Charleville, Kilcomer, and Doneraile; Rev. T. Allin.

Sium latifolium (Linn.)—7. East side of the Shannon at Portumna Bridge; M. Dowd.

S. angustifolium (Linn.)—4. Curacloa, Wexford; Miss E. M. Farmer. —5. In the Canal near the North Strand, Dublin; M. Dowd. District 10. In the County Fermanagh; Mackay Rar.

Œnanthe Phellandrium (Lam.) District 7. Common about Parsonstown; also at Oldcastle, Westmeath; M. Dowd.

†*Æthusa Cynapium* (Linn.) District 7. Parsonstown; M. Dowd.

‡*Fœniculum officinale* (All.)—12. On both sides of Killough Bay, Down; S. A. Stewart.

Haloscias scoticum (Fries).—11. Plentiful on rocks in Downing's Bay, near Carrigart; also at Dunaff Head; H. C. Hart.—12. Donaghadee and Copeland Isles; Templeton.

‡*Pastinaca sativa* (Linn.)—2. Near Ardmore, Waterford; Rev. T. Allin. District (11.) Donegal Castle; H. C. Hart.

Torilis nodosa (Gaert.)—4. Valley of Diamonds, Bray; R. M. Barrington.—6. Isles of Aran; H. C. Hart.—12. Frequent on the coast of Down; S. A. Stewart. Dunseverick; R. Tate.

Scandix Pecten-Veneris (Linn.) District 7. Parsonstown; M. Dowd.

†*Anthriscus vulgaris* (Pers.)—2. Sparingly on a wall near some farm buildings at Ballyvodock; Rev. T. Allin. District 3. Roadside between Browne's Hill and Carlow; and near Ballinacarrig; R. Clayton Browne. Roadside between Mountrath and the railway station; T. Chandlee. District 6. About Kilronan, Aran; H. C. Hart.

Chærophyllum temulum (Linn.)—5. Hedge near Old Connaught; R. M. Barrington. District 7. Roadside one mile north of Oldcastle, Westmeath; M. Dowd.

Conium maculatum (Linn.) District 7. Parsonstown; M. Dowd.

Hedera Helix (Linn.) The so-called "Irish" Ivy has not yet been found growing in any place where it can be considered native. The Ivy of Kerry and Aran is only typical H. Helix.

Cornus sanguinea (Linn.)—6. On all three Isles of Aran, especially by the shore west of Killeany; H. C. Hart.—10. Banks of the Colebrooke river, Fermanagh, apart from any shrubberies; T. O. Smith.

‡*Sambucus Ebulus* (Linn.) District 7. Roadside between Parsonstown and Frankford; M. Dowd.

Galium cruciatum (Linn.) District 12. This plant was recorded in the "Antient and Present State of the County of Down," 1757, as occurring then "among the rubbish of the Cathedral of Downpatrick;" and the authority "Is. Butler" is added after these very words by the Annotator in the copy of Threlkeld belonging to the library of the Royal Irish Academy. It was rediscovered about 1842 by Professor

J. E. Hodges, at the bottom of a field adjoining the marshes near the Cathedral, and on the side of the old Rath; as we learn from a letter addressed to W. Thompson in June, 1842, and for the knowledge of which we are indebted to our active correspondent Mr. S. A. Stewart. Again gathered in 1868, by the Rev. W. E. Mulgan, who has observed it for the last few years growing in a field near Downpatrick Cathedral. District 10. Plentiful in boggy ground by the side of a small lake at Colebrooke, Fermanagh, 1869 (found by Mr. T. O. Smith); H. C. Hart.

Galium boreale (Linn.)—9. By Lough Bofin, Leitrim; W. T. Dyer. 12. By the river in Glenarm Deer park; R. Tate.

G. erectum (Huds.) District (2.) Sparingly in two lawns near Middleton and Ballinacurra, introduced; Rev. T. Allin.—5. In the demesne at Kilkea Castle! J. Douglas.

G. Mollugo (Linn.) District 4. By the avenue at Vallumbrosa, Bray; R. M. Barrington.—5. Near Kilkea Castle, Kildare; J. Douglas.

G. uliginosum (Linn.) District 7. On a bog near Multifarnham, Westmeath, sparingly, 1871 and 1872; D. M. District 12. In the County of Antrim; Rev. W. M. Hind (in Herb. Trinity College); Dr. E. P. Wright.

[*Valerianella carinata* (Lois.) District 10. Abundant on hedge-banks for a mile along a bye-road crossing Holywood Hill, near Dundonald, Co. Down; S. A. Stewart, 1871. If permanent in this locality, it will deserve to be considered a "Colonist;" for the present it ranks as a "Casual" only].

V. Auricula (D. C.)—2. Little Island, Cork, and frequent in both divisions of the County; Rev. T. Allin. Also in fields at Doughtans, Waterford; *idem.*

V. dentata (Deitr.)—3. Noreville, Queen's County; J. Morrison.—12. Carnlough; R. Tate. Island Magee and near Dundonald; S. A. Stewart.

Dipsacus sylvestris (Linn.)—2. Fields near Youghal; Rev. T. Allin. Abundant by the old road between Ross and Waterford; J. Morrison. District 4. By the road from Horetown, and Whitechurch, and Kilmokea, Wexford; Miss E. M. Farmer. Duncannon; R. M. Barrington.

Knautia arvensis (Coult.) District 11. Fields near Lough Esk, Donegal; H. C. Hart.—12. Between Randalstown and Cookstown Junction; R. Tate.

Erigeron acris (Linn.)—3. Mountmellick; J. Morrison.—5. About Mullaghchreelan Hill, Kildare; J. Douglas.

‡*Inula Helenium* (Linn.)—1. Near the ruins on Church Island in Lough Currane, Waterville; A. G. M. Frequent in Cork, and particularly in the islands of Cape Clear; Annot. in Threlkeld. District 11. The Little Bins Greenfort, Fanet; H. C. Hart.

Inula crithmoides (Linn.)—2. Rocks at Ardmore, Waterford; Rev. T. Allin.

Bidens tripartita (Linn.) District 3. Castle Blunden, Kilkenny; Rev. S. Madden.

†*Anthemis arvensis* (Linn.)—5. Plentiful in sandy cultivated ground at Portmarnock, 1869; A. G. M.

Diotis maritima (Cass.) District 4. Near Carnsore Point, Wexford; (John Waddy), Symes' Engl. Bot.

Artemisia maritima (Linn.)—5. On a low muddy point south side of the estuary of the Boyne below Drogheda, and sparingly on the adjacent shore; A. G. M.

**Tanacetum vulgare* (Linn.) District 6. Middle Island of Aran; H. C. Hart.

Filago minima (Fr.)—4. Roadside near Drumgoff, and on the Murrough of Wicklow; A. G. M.—12. Sands east of Portrush; R. Tate.

Gnaphalium sylvaticum (Linn.) District 3. In the county of Caterlough (Carlow); Threlkeld. On high ground near Myshall, Carlow; R. Clayton Browne. District 4. In our walk towards Powerscourt; Annot. in Threlkeld. Near Shillelagh, Wicklow; H. C. Hart. District 11. Near Milford and Fanet, Donegal; Rev. T. Allin.—12. Ballintoy; R. Tate.

Antennaria dioica (Gaert.)—3. Near the Black Bog, Carlow; R. Clayton Browne. Wet pasture at Ashbrook, Queen's County; J. Morrison.

Senecio erucifolius (Linn.) District 4. Near Bray; D. M. Old Court near Bray; R. M. Barrington.—5. Castleknock, Lucan, Stillorgan and Tallaght; A. G. M.

S. Jacobæa (Linn.) Var. without rayed florets. *S. flosculosus* (Jordan). On several parts of the coast, but local. District 1. Ferriter's cave, Kerry; A. G. M. District 2. Near Tramore, Waterford; J. Woods in "Phytologist." District 4. Near Churchtown, Wexford (J. Waddy); Symes' Engl. Bot. District 5. Sandhills between Gormanstown and Maiden Tower, in many places; A. G. M. 6. In Great Aran; D. Oliver. Frequent in Aran, but the ordinary form occurred in one field only; H. C. Hart. District 8. On several islands off Connemara; A. G. M.

**S. squalidus* (Linn.) The supposed hybrid between this and *S. vulgaris* (Linn.) proves to be the rare variety of *S. vulgaris* with ligulate florets, which has also been found by Mr. N. Moore at Lough-annure, Donegal.

**Senecio saracenicus* (Linn.)—1. Roadside at Bantry; Rev. T. Allin. District 5. Near Clonskeagh, Dublin; Annot. in Threlkeld. District 6. Near Corrofin, Clare, and in Pallas, Galway; K'Eogh, p. 108.—12. By the river near C. G. Station at Cushendall; Dr. J. S. Holden.

Carlina vulgaris (Linn.)—3. Near the Black Bog, Carlow; R. Clayton Browne.—4. Near Courtown; Miss E. M. Farmer. Near Enniscorthy; J. Morrison.

Arctium majus (Schk.) Mr. Allin has not succeeded in finding this plant in the county of Cork, and we have as yet seen no Irish

specimens. Professor C. C. Babington informs us that his specimen is too imperfect to be considered quite satisfactory.

A. intermedium (Lange). *A. pubens* (Bab.) District 6. In the Isles of Aran; H. C. Hart.—12. Common on the coast of Antrim, where *A minus* has not been observed; R. Tate.

Centaurea Scabiosa (Linn.) District 4. At Greystones near the church; Mrs. G. Dixon. Roadside near Greystones; Rev. J. H. Jellett. Shore at Kilkool; H. C. Hart.—6. Between Galway and Athenry; S. A. Stewart. Common in all three Isles of Aran; H. C. Hart.

[*Centaurea paniculata* (Lam.) A single plant in a cultivated field on the coast north of Rush; M. Dowd, 1870. No doubt accidentally introduced.]

Carduus tenuiflorus (Curt.)—3. Near Garryhundon, Carlow; R. Clayton Browne.—5. Roadside banks near the Hill of Tara; A. G. M.

Carduus arvensis (Curt.) [Var. *setosus* (M. B.)—11. In a stubble-field by the River Lennon, near Kilmacrenan, Donegal; Rev. T. Allin. The curious plant, gathered by Mr. Allin, at first sight looks like some hybrid, but it has the essential character of *C. arvensis*. The leaves are shaped somewhat like oak leaves]

**Silybum Marianum* (Gaert.) District 6. On great Aran Island; H. C. Hart.—12. Port Bradden and Toome Bridge and shores of Lough Neagh, three miles from Toome; S. A. Stewart.

‡*Cichorium Intybus* (Linn.)—2. Field by the Blackwater, in Waterford; Rev. T. Allin. District 3. Near Ballyonskill, Kilkenny; Rev. S. Madden.—4. Occasionally at Fassaroe, near Bray; R. M. Barrington.—12. On the mountains of Mourne; Harris' Hist. of Down.

Thrincia hirta (D. C.) District 3. Common about Carlow; R. Clayton Browne. District 7. Frequent about Parsonstown; M. Dowd. District 12. Near Newtown-Breda and banks of Laggan, above Ward's Cottage! D. Orr. The last is the station given for *Apargia hispida*, in "Flora Belfastiensis."

Var. arenaria (D. C.) Seaside sandhills at Courtown, Portraine and Gormanstown; A. G. M.

Apargia hispida (Willd.)—4. Roundwood, and—5. Lucan; A. G. M. Never seen in the north of Ireland by Mr. D. Orr, who believes that *T. hirta* has often been mistaken for it.

Tragopogon pratensis (Linn.) District 3. Woodstock, Kilkenny; Miss E. M. Farmer.—4. Near Rathnew, Wicklow (*T. majus*); A. G. M. Fassaroe; R. M. Barrington.—5. Common at Straffan and Kilkea; J. Douglas.

Helminthia echioides (Gaert.)—2. Near Youghal; Rev. T. Allin. District 12. Shore at north end of Island Magee, opposite Larne, Antrim; S. A. Stewart and R. Tate. Shore of Belfast Bay, half a mile above Blackhead; S. A. Stewart.

Leontodon Taraxacum (Linn.) *Var. palustre* (Sm.) District 10. Occasionally in Tyrone; Dr. Sigerson.—12. Shores of Lough Beg (*T. udum!* Jordan); S. A. Stewart.

Sonchus asper (Hoffm.) District 11. Fanet, Donegal; H. C. Hart.

†*Crepis* (*Barkhausia*) *taraxacifolia* (Thuil.) *C. biennis* (Flor. Hib. —5. This plant is still spreading, with every appearance of an introduced species, in the neighbourhood of Dublin. Raheny; H. C. Hart. At Portmarnock and Malahide; Hedgebanks, near Lucan, Quarry near Finglas-wood; and on the south side of Killiney Hill; A. G. M. Vallumbrosa, near Bray; R. M. Barrington.

[*C. setosa* (Hall). Field between Browne's Hill and Carlow! 1867; R. Clayton Browne].

C. paludosa (Moench.)—2. By the River Lickey, in Waterford, and by the river near Middleton, Cork; Rev. T. Allin. District 7. Plentiful in wet pastures north of Oldcastle, Westmeath; M. Dowd.

Hieracium anglicum (Fries). District 2. Rocks above Gurthaveha Lake near Millstreet; A. G. M. District 6. On a granite boulder, in Great Aran Island; H. C. Hart.

H. boreale (Fries.) District 11. Near the mill at Ardara; H. C. Hart.

[*Campanula rapunculoides* (Linn.) Sandhills at Newcastle, Down, about 50 plants in 1871, and, no doubt, introduced; S. A. Stewart. A few plants at the foot of a wall near the harbour of Bray, 1872; A. G. M.]

Obs. *Campanula latifolia* (Linn.) Has not yet been rediscovered on the banks of the Barrow above New Ross, and it is much feared that a mistake was made in the name, especially as Mackay records only *C. latifolia* from the same district where other botanists have found *C. Trachelium* only.

C. Trachelium (Linn.)—(4.) In a field near Roundwood, towards the Reservoir; Hon. Mrs. Barton.

Wahlenbergia hederacea (Reich.)—1. Banks of a stream west of Macroom (found by Miss J. Harvey); Isaac Carroll. District 5. In Glen-cullen, near the bridge; Greenwood Pim.

Andromeda polifolia (Linn.)—3. Common on bogs in Queen's County. Mackay Rar.—7. On Annahinch Bog, near Parsonstown; G. H. Kinahan. Add Districts 6, 7, 9, 10, 12, which were accidentally omitted in the line of figures.

Erica cinerea (Linn.) Ascends to 2200 feet on Sawel, Derry; D. M. To 2300 feet on Mangerton, and to 2500 feet on Carn Tual, Kerry; A. G. M.

Calluna vulgaris (Salisb.) Ascends to 3300 feet on Carn Tual; A. G. M.

Erica ciliaris (Linn.) This must be very rare in the locality near Craigga-more, and neither D. M. nor A. G. M. have been able to find it, but Professor Balfour has kindly sent us a specimen gathered in 1852.

Obs. *Erica vagans* (Linn.) Mr. R. M. Barrington, having been directed by Doctor Burkitt to the exact spot where it was supposed to have been gathered, has made a careful search without finding a trace of this plant: see "Trimen's Journal of Botany," p. 108 (1872.)

Pyrola rotundifolia (Linn.) District 7. Sparingly on a large bog

near Multyfarnham, Westmeath, 1870; D. M. How's locality, "In a bog by Roscree," may belong to this species.

P. minor (Linn.)—7. In a glen near Tyrrell's-pass; D. M. District 10. Hill of Scraba, near Newtown; Harris's "Down."

Monotropa Hypopitys (Linn.) District 9. Hazlewood, Sligo; (found by Miss Wynne) Lord Clermont.

Ilex Aquifolium (Linn.) District 10. Near Strabane; Dr. Sigerson.

Ligustrum vulgare (Linn.) District (10.) Banks of the Glenmornan river, Tyrone, introduced; Dr. Sigerson.

Erythræa pulchella (Fries). District 4. Curacloa, Wexford! J. Morrison. District 5. On the North Bull! Dublin Bay, in tolerable plenty, October 1867; D. Orr.

E. Centaurium (Pers.) District 10. Cloghcor, Tyrone; Dr. Sigerson. The *Var. latifolia* is *E. capitata* (R. et S.)

Convolvulus arvensis (Linn.)—6. Plentiful near Limerick; D. M. In the great Island of Aran; H. C. Hart. District 9. In County Sligo; I. Carroll.—10. Fermanagh; Rev. S. A. Brenan. District 11. Fanet, Donegal; H. C. Hart.—12. Glenarm; Dr. J. S. Holden. Between Rathmullan and Tyrella, Down; S. A. Stewart.

C. sepium (Linn.) District 10. Enniskillen, Fermanagh; S. A. Stewart. By the Foyle and near Strabane; Dr. Sigerson.

**Cuscuta Trifolii* (Bab.) District 4. Quite established in clover fields at Fassaroe, near Bray; R. M. Barrington. District 5. Found in 1868, by Dr. W. G. Smith, in a field near the sea-shore at Ballybrack, occupying a space of a few square yards only, and here parasitical upon *Lotus, Daucus, Linum catharticum*, etc. ("Dub. Nat. Hist. Soc., Proc., vol. v., p. 198.) Once found near Kilkea, Kildare; J. Douglas.

‡*Cynoglossum montanum* (Lam.) Probably not native, in the single locality near Balbriggan.

**Anchusa sempervirens* (Linn.)—11. At Clondevaddock Church, Rossnakill, Fanet; H. C. Hart.

Lycopsis arvensis (Linn.)—5. Shore north of Gormanstown, and at mouth of Boyne; A. G. M. District 11. By Lough Swilly, and near the light-house, Fanet; H. C. Hart.

Echium vulgare (Linn.)—4. Near Ballycarney and Bloomfield, Wexford; Miss E. M. Farmer. At Fassaroe, near Bray, occasionally; R. M. Barrington.—5. On the warren south of Rush, plentifully; shore at Gormanstown and at Laytown; A. G. M.—12. Curran of Larne; R. Tate. Cushendun, but very rare; Rev. S. A. Brenan.

Mertensia maritima (Don).—4. Not now plentiful on the Murrough of Wicklow, but occurs near Newcastle Station, and between Kilcool and the "Breaches;" A. G. M. District 6? Sands at mouth of Creagh river, near Mount Rivers, Clare; "Dublin Penny Journal," iii., 278.

Lithospermum officinale (Linn.) District 4. Between Ballymoney and Kiltennel sandbanks; Miss E. M. Farmer. Among bushes on the shore north of Courtown; A. G. M. Fassaroe, Bray; R. M. Barrington.—6. Great Aran Island; H. C. Hart. District 11. Rathmullan and Downing's Bay, Donegal; H. C. Hart, Ballyhooriskey; Rev. T. Allin.

Myosotis repens (Don). District 10. Castle Derg, Tyrone; S. A. Stewart.

Solanum nigrum (Linn.) District 4. Shore near Churchtown, Wexford, first observed in 1834, and still growing there in 1869; also on sands at Rostonstown; John Waddy.—5. Once seen in the churchyard at Kilkea, Kildare; John Douglas.—12. Sandy ground near Cushendun, from 1867 to 1871; Rev. S. A. Brenan.

S. Dulcamara (Linn.)—3 and 4. Occasionally in the counties of Carlow and Wexford; J. Morrison.—4. St. John's, near Enniscorthy; Miss E. M. Farmer.—11. At Leck, on the farmyard wall, and in a hedge a mile towards Stranorlar; N. Moore.

Hyoscyamus niger (Linn.)—3. Browne's Hill, Carlow; R. Clayton Browne. Maryborough, Queen's County; J. Morrison. 4. Bannow, Wexford; Miss Nunn. On the Murrough, a little north of Wicklow; A. G. M.

Orobanche rapum (Thiel.)—5. On a hill south of Rathfarnham; Annot in Threlkeld.

O. rubra (Sm.)—12. On white limestone at Ballyvoy and White Park, Ballintoy; R. Tate.

O Hederæ (Duby).—9. Hazlewood, Sligo; D. M.

[*O. minor* (Linn.) District 4. On clover in two fields at Springhill, Enniscorthy, 1868; J. Morrison. A single plant next a Sweet Pea in the garden at Bloomfield, and another single plant on clover by the avenue at Bloomfield, 1867; Miss E. M. Farmer. Scarcely yet established as a naturalized plant].

Lathræa Squamaria (Linn.)—2. Plentiful for a long distance along the banks of the Blackwater, below Mallow, parasitical on *Ulmus montana* only, avoiding Beech, Horse Chestnut, Alder, and Sycamore; A. G. M. District 7. In woods at Parsonstown, but rather scarce; M. Dowd. District 9. In County Roscommon ! Miss Acton.—10. Whitepark, Fermanagh; T. O. Smith.

Verbascum Thapsus (Linn.) District 11. Between Ballyshannon and Donegal; H. C. Hart.

* *V. Blattaria* (Linn.)—4. On rough stony ground a little north of Wicklow; A. G. M.

Antirrhinum Orontium (Linn.)—2. Fields near Tower Village, Blarney (found by Mr. R. Mills); Rev. T. Allin.

Linaria Elatine (Mill.) District 4. Between Bannow and Ballymadder, Wexford; R. M. Barrington.—6. Roadside near Ballyvaughan, Clare; Rev. T. Allin.

L. minor (Desf.)—3. Browne's Hill, Carlow; R. Clayton Browne. Railway embankments near Carlow, not Enniscorthy; J. Morrison.—5. Near Sydney Parade Station, 1867; V. A. Smith. Straffan, Kildare; J. Douglas.

L. repens (Ait.)—5. Perhaps introduced at Bushy Park; D. M.; and the locality near Carlow requires confirmation.

L. vulgaris (Mill.)—3. Garryhill, Carlow; R. Clayton Browne. 4. Frequent near Enniscorthy; Miss E. M. Farmer.

Scrophularia aquatica (Linn.) District 3. Kilmacow, Kilkenny; T. Chandlee. District 11. Drimnacraig and in Fanet; H. C. Hart.

Melampyrum pratense (Linn.) District 3. Banks of the Slaney; R. Clayton Browne.

M. sylvaticum (Linn.)—12. Crow Glen, Belfast; S. A. Stewart.

[*Mimulus luteus.* (Willd.)—4. In the Dargle River, near Enniskerry; A. G. M.—10. On waste ground near the Glenmornan River, Tyrone, two or three plants only; Dr. Sigerson.—12. Banks of the Bann, between the Cuts and Coleraine; S. A. Stewart].

Pedicularis sylvatica (Linn.) District 11. Common about Horn Head; N. Moore, and in Fanet; H. C. Hart.

Rhinanthus Crista-galli (Linn.) District 10. Enniskillen, Fermanagh; S. A. Stewart.

Veronica officinalis (Linn.) District 10. Sperrin Mountains, Tyrone; S. A. Stewart.

* *Veronica peregrina* (Linn.) District 9. Demesne at Rockingham, Roscommon, and in the garden and demesne at Hazlewood, Sligo; D. M. District 11. Salthill Garden, Mount Charles, and Kilderry, Muff, 1870; H. C. Hart. Gweedore; Rev. W. M. Hind. Not found in District 6.

* *V. Buxbaumii* (Ten.) District 11. Rathmullan; H. C. Hart.

V. hederifolia (Linn.) District 7. Parsonstown; M. Dowd.

‡*Mentha sylvestris* (Linn.) District 2. Roadside near Timoleague, 1871; Rev. T. Allin.

†*M. rotundifolia* (Linn.)—2. Fields near the Blackwater, Waterford; Rev. T. Allin. District 6. Roadside banks between Galway and Oranmore; S. A. Stewart. Cultivated in the garden of the Atlantic Hotel, at Kilronan, Aran; A. G. M.—8. Plentiful near a cottage at Ballinaderg Bridge, at foot of Nephin; H. C. Hart.

**M. piperita* (Sm.)—2. Near the river at Middleton, plentifully; Rev. T. Allin.

M. sativa (Linn.) District 11. Near Croagross, Fanet; H. C. Hart. Ditto *var. rubra* (Smith).—4. Clohass Bog and Bloomfield; Miss E. M. Farmer.

M. arvensis (Linn.) District 3. Mountrath, Queen's County; J. Morrison. District 10. Near Liscurry, Tyrone; Dr. Sigerson. District 11. Near Cloghanealy; N. Moore. Fanet; H. C. Hart.

M. Pulegium (Linn.)—2. Abundant near Kilcoleman; Rev. T. Allin.

[*M. Requienii* (Benth.) The Corsican Mint has been observed by the Rev. T. Allin, growing abundantly in the street of Castle Townsend, evidently an escape from cultivation].

Salvia Verbenaca (Linn.)—2. Near Red Strand, Clonakilty; Rev. T. Allin.

Calamintha officinalis (Moench.)—2. Near Blackwater, Waterford, and abundant on limestone in North Cork; Rev. T. Allin.

Obs. *Calamintha Nepeta* (Clairv.) Must be struck off the Irish list, as Professor Babington informs us that his specimen belongs to *C. officinalis*.

C. Acinos (Clairv.)—5. Once found sparingly near Mullaghchreelan Hill, Kildare; J. Douglas. Portraine, 1869; H. C. Hart.

C. *Clinopodium* (Benth.) District 9. On the shore of the lake at Rockingham, Roscommon, 1871; D. M. It is to be feared that many of the localities given for this plant, especially those near Dublin, belong to *C. officinalis.*

Scutellaria galericulata (Linn.) District 11. Mulroy and Carrowkeel, Fanet; H. C. Hart.

†*Nepeta Cataria* (Linn.)—5. Ditch near the Curragh of Kildare, 1732; Annotator in Thelkeld, R. I. A. District 7. Roadside near Ballylucnane, Parsonstown; M. Dowd. District 10. Banks of the Colebrooke River, Fermanagh; T. O. Smith. District 11. In a lane from Rowross Ferry to Carrigart, and one plant between Donegal and Ballyshannon; H. C. Hart.—12. Waste ground near Ardglass, Down, perhaps an escape; S. A. Stewart.

Lamium amplexicaule (Linn.)—5. Kilkea Castle, Mageney; J. Douglas. District 11. Fanet and Rossnakill; H. C. Hart.

L. intermedium (Fries).—12. Along the coast from Magilligan to Belfast, in various places, extending as far south as Newtownards; R. Tate.

†*L. album* (Linn.)—4. Near the bridge at Bray; R. M. Barrington.—5. Common about Kilkea, Kildare; J. Douglas. South shore of the Boyne below Drogheda, and near the Hill of Tara, Meath; A. G. M.

L. Galeobdolon (Crantz).—5. Kelly's Glen, on the upper Dodder; W. Archer.

Galeopsis Ladanum (Linn.)—4. Every year in wheat crops at Fassaroe, near Bray; R. M. Barrington.

Stachys Betonica (Benth.) District 7. Woods near Tullagh, barony of Onagh, Tipperary; K'Eogh Bot. Hib.

S. arvensis (Linn.) District 4. Shillelagh, Wicklow; H. C. Hart. Between Ballymadder and Bannow, Wexford; R. M. Barrington. District 6. In Great and Middle Aran; H. C. Hart. District 11. Frequent in Fanet; H. C. Hart.

Ballota nigra (Linn.)—4. Plentiful a few years ago near Enniscorthy; J. Morrison. District 11. Between Salthill and Ardnamona, Donegal; H. C. Hart.—12. Shores of county Down, in several places; S. A. Stewart.

Teucrium Scordium (Linn.) District 9. Banks of the Shannon near Lanesborough, fide I. B. (Isaac Butler), Annot. in Threlkeld.

Pinguicula grandiflora (Linn.)—2. At Gurthaveha Lake, near Millstreet, sparingly. Ascends to 1800 feet on Carn Tual; A. G. M.

P. vulgaris (Linn.)—1. In the Horse's Glen, Mangerton, with *P. grandiflora*, at about 1800 feet; A. G. M.

Utricularia intermedia (Hayne).—1. Bog holes near Lough Carragh; Dr. Battersby. Bog near Knockskeagh, Leap; Rev. T. Allin.—11. Near Kindrum Lakes, Fanet; H. C. Hart.

U. minor (Linn.) District 2. Dunsfort Bog, near Middleton, But-

tevant, and other places in East Cork, frequent; Rev. T. Allin. District 3. Bog of Allen; *Wade, Rar.*

Hottonia palustris (Linn.)—12. Plentiful in the drains on the bog meadows, Belfast, where it was planted a few years ago; S. A. Stewart. Dr. P. Browne notes it as found in a watery ditch west of Lough Mask, on the road from Ballinrobe to Westport, but this latter locality requires to be verified before the plant can be admitted as a native of the west of Ireland.

‡*Lysimachia Nummularia* (Linn.)—4. Under a bank outside a boggy plantation between Monart-house and Mill-house, Wexford; Miss E. M. Farmer. 10. River bank, near Ardunshin, Fermanagh; Rev. S. A. Brenan. Banks of the river three miles above Colebrooke; T. O. Smith. 12. Dunminning, near Ballymena; apparently an escape from cultivation; N. Moore. *L. nemorum* has often been mistaken for this species.

Anagallis arvensis (Linn.) *Var. cœrulea.* District 5. Sparingly near Kilkea Castle, Kildare; J. Douglas. District 8. Near Belmont, Galway; Dr. W. King.

Centunculus minimus (Linn).—1. Shores of Berehaven; A. G. M. 2. Ballintowtas, near Middleton, Cork; Rev. T. Allin.

Samolus Valerandi (Linn). District 3. Browne's Hill, and on the Black Bog, near Carlow; R. Clayton Browne.

Statice occidentalis (Lloyd). District 4. Rocks about two miles north of Arklow, and near the old castle at Wicklow; A. G. M.—5. On the North Bull, Dublin, sparingly, and on the muddy shore of the creek north of Malahide: on the flat shore at the north end of Portraine, and on the drier part of a mud flat at Laytown, in several of these localities accompanied by *S. Bahusiensis;* A. G. M.

Armeria maritima (Willd.)—1. On the shores of Ross Island, Killarney, growing with *Silene maritima.* Ascends to 3400 feet on Carn Tual; A. G. M.

Plantago maritima (Linn.) District 8. Frequent on the coast of Connemara, etc.; A. G. M.

[*Plantago media* (Linn.) Reported by Mr. J. Douglas as found by him abundantly in a field and on a furzy bank about one and a-half miles north of Straffan, Kildare; but not having seen any specimens, and not knowing the circumstances under which it occurred, we still hesitate to admit it as a native plant. A variety of *P. lanceolata,* with very broad leaves, occurs about Feltrim Hill, and was, probably, mistaken by Mr. White for *P. media.* This variety has also been sent to us from the north of Ireland, under the name of *P. media.*]

Littorella lacustris (Linn.) District 2. Shore of Ballybutler Lake, near Middleton, and at Kilcoleman, Castlemartyr, etc.; Rev. T. Allin.

Suæda maritima (Dum.) District 6. Great Aran Island; Dr. E. P. Wright.

Salsola Kali (Linn.) District 6. Great Aran Island; *idem.*

Chenopodium album (Linn.) District 7. Parsonstown; M. Dowd.

C. rubrum (Linn.) District 2. Edge of a bog at Kilcoleman, with *Rumex maritimus;* Rev. T. Allin.

Obs. *C. urbicum* (Linn.) Has not been rediscovered, and we fear that *C. murale* was the plant gathered in Upper Dominick-street.

Atriplex littoralis (Linn.) District 6. Great Aran Island; H. C. Hart. District 11. Lighthouse at Fanet; *idem.*

A. angustifolia (Sm.) District 6. Aran; H. C. Hart. District 7. Parsonstown; M. Dowd. District 11. Fanet; H. C. Hart.

A. hastata (Linn.) District 7. Parsonstown; M. Dowd.

A. arenaria (Woods.)—5. Sandy shore at Portraine, and Gormanstown, and south bank of the estuary below Drogheda, but quite rare; A. G. M. Not seen on the coast of Antrim by Mr. R. Tate.

Obione portulacoides (Moq.)—5. Rocks at south side of, and on the flat shore at north end of Portraine opposite Rush; also on the south side of the estuary below Drogheda; A. G. M. Salt marsh on south side of Dundalk Bay; Templeton.

Rumex maritimus (Linn.) District 2. Sparingly on the edge of a bog at Kilcoleman! Rev. T. Allin.

‡*R. pulcher* (Linn.) District 4. On the shore by the harbour at Bray, 1867-72; D. M.—5. Shore near the Race-stand at Baldoyle, 1868, very sparingly; A. G. M.

R. Hydrolapathum (Huds.)—2. Abundant near Buttevant, Cork, and Cappoquin, Waterford; Rev. T. Allin.

†*Polygonum Bistorta* (Linn.)—3. In Captain Mitchel's ground by the brook near Stradbally, 1732; Annot. in Threlkeld. This is, probably, the very same locality where it was observed by Mr. Chandlee 130 years later.

P. Raii (Bab.)—1. Sandy point at entrance to the harbour of Ardgroom, Cork; A. G. M.—5. Shore north of Gormanstown; A. G. M.

**Hippophae rhamnoides* (Linn.) District 4. Thoroughly established on the sandhills at Kiltennel, north of Courtown, Wexford, where Miss Farmer has ascertained that it was planted about thirty years ago. Mr. J. Morrison informs us that this shrub grows also on the sandy shores at Raven Point, near Wexford Harbour. (5). Planted at Rush.

Empetrum nigrum (Linn.) District 3. Plentiful on Mount Leinster, on the borders of Carlow and Wexford; R. Clayton Browne. District 7. Tops of mountains four miles from Parsonstown; M. Dowd. District 10. Sperrin mountains, Tyrone; S. A. Stewart. Occurs on many of the mountains near Killarney and on Connor Hill; A. G. M.

Euphorbia hyberna (Linn.) District 11. Among large rocks and bushes on the south side of the Poisoned Glen, Dunlewy, Donegal, in no great quantity; N. Moore, 1867—thus confirming the accuracy of Robert Brown's observation. This spurge flowers in the early Spring, commencing often in the middle of April. It frequently grows on open rocky banks, and among heath on the mountains, ascending to 1500 feet or more in the Horse's Glen, Mangerton; A. G. M.

E. amygdaloides (Linn.) District 4? A single plant has been ob-

served for several years past growing in ground now cultivated on the site of a former wood near Springhill, Enniscorthy; J. Morrison. Whether a recent introduction, or a relic of a former wild station, cannot be determined, but this, at least, indicates that the plant should be sought in the neighbourhood of Enniscorthy.

E. portlandica (Linn.)—1. Derrynane, Kerry, sparingly; A. G. M. Rosscarbery, Clonakilty, and Castlefreke, Cork; Rev. T. Allin.—4. Sandhills at Courtown and Arklow; A. G. M. District 6. Great and Middle Aran; H. C. Hart.—11. Kindrum, Donegal; *idem.*

Mercurialis perennis (Linn.)—10. In the lower demesne at Tandragee, plentiful in one spot; R. M. Barrington.

Ceratophyllum demersum (Linn.)—2. Blarney Lake (found by R. Mills); Rev. T. Allin.—12. In the Quoile river, Downpatrick; S. A. Stewart. Not found in Lough Neagh, which was given in mistake for Lough Leagh, near Killaleagh, Down, where the plant was found by Templeton in 1804.

Callitriche autumnalis (Linn.) District 1. By the shore of Ross Island, Lower Lake of Killarney, 1866; A. G. M. This will alter the latitude from 53° to 52°, and is the most southern locality in the British Islands.—12. Carrickmannan Lake, near Saintfield, Down; S. A. Stewart.

Salix pentandra (Linn.) District 3. Many scattered trees in the uncultivated country between Mountmellick and Tullamore; J. Morrison.—9. In hedges and by ditches in Glen Iff, Ben Bulben; W. T. Dyer.—12. Common in the Tickmacrevan district, Glenarm; R. Tate.

**S. purpurea* (Linn.) *Var. Helix* (Linn.) District 9. Glen Iff, Ben Bulben, and near Drumod, but planted; W. T. Dyer.

S. phylicifolia (Linn.) District 9. North side of Ben Bulben; D. M. This is the willow given in our "Contributions," under the name of *S. procumbens*, which must now be expunged.

S. ambigua (Ehrh.) District 8. Tully, Connemara; Professor C. C. Babington.

S. Grahami (Borr.) District 11. Among moss on the top of Muckish Mountain, Donegal, 1868; D. M. Mr. Leefe considers this little willow very closely allied to the continental *S. retusa* (Linn.)

S. herbacea (Linn.)—1. On Carn Tual at 2650 feet; A. G. M.—8. On Lettery Mountain, etc., in Connemara; Mackay, Rar. The height of 1000 feet, at which this plant grows, on the top of Clontygearagh Mountain, Derry, is lower than any elevation at which it has been observed anywhere else in Great Britain.

Quercus Robur (Linn.) *Var. sessiliflora* (Sm.) District 1. Killarney; A. G. M. District 10. Banks of the Glenmornan river, Tyrone; Dr. Sigerson.

‡*Tamus communis* (Linn.) District 9. On a bushy hill rising from Lough Gill, looking eastwards, and within the demesne of Hazlewood; Dr. T. E. Little, 1866. Abundantly in a wood on the shore of Lough Gill, far from any house or garden; W. Heron, 1868. Seen in this locality by D. M., in 1871, but was very probably planted there by the

late owner of Hazlewood, who was very fond of introducing new plants in his demesne. *Tamus* is not mentioned in the late Mr. Wynne's own list of the plants seen by him in Sligo, and yet it could hardly have escaped his observation at Lough Gill.

**Anacharis Alsinastrum* (Bab.) *A. canadensis* (Planch.) District 4. Ponds at Hollybrook, Bray; R. M. Barrington. Is rapidly extending along the canals and rivers throughout nearly all Ireland.

Orchis Morio (Linn.)—8. Foot of Urrisbeg mountain near Roundstone; W. T. Dyer.

O. pyramidalis (Linn.) District 1. Meadow near Passage, and on sandhills near Castlefreke; Rev. T. Allin.—3. Common about Carlow; R. Clayton Browne.—4. Sandhills north of Arklow; A. G. M. District 11. Near Kindrum Lake, Fanet, Donegal; H. C. Hart.

Gymnadenia albida (Rich.)—6. Two miles north-west of Woodford, Galway; M. Dowd.—9. Bruse Hill, near Mohill, Leitrim; the late F. J. Foot.

Neotinea intacta (Reich.)—6. Has been gathered every year since 1864 in the original locality, but has not yet been found anywhere else near Castle Taylor, except in the one large pasture field in which it was first discovered. District 9. On the north-east shore of Lough Corrib, not far from Cong, April, 1872; D. M. Flowers early, commencing at the end of April.

Habenaria bifolia (R. Br.)—4. Marshes near Newcastle, Wicklow; A. G. M.—7. Near Parsonstown; M. Dowd. This appears to be a scarce plant, while *H. chlorantha* is very frequent, especially in heathy districts, ascending to 700 or 800 feet.

Ophrys apifera (Huds.)—4. Sandbanks at Kiltennel and Courtown, Wexford; Miss E. M. Farmer.

Spiranthes autumnalis (Rich.)—1. Three Castle Head, Cork; T. Chandlee.—2. Near Lecky, and by the Blackwater, Waterford; Rev. T. Allin.

Spiranthes Romanzoviana (Cham.) This is the name now adopted by Prof. Asa Gray, and Dr. Hooker, in preference to *S. gemmipara*. The plant still grows in many of the meadows and pastures near Castletown, commencing to flower from the middle of July.

Listera cordata (R. Br.)—4. On the mountain side south of Lough Nahanagan, Wicklow; A. G. M.—5. Kelly's Glen; C. Ball.—11. Hills near Rathmullan, Donegal; H. C. Hart.

Neottia Nidus-avis (Rich.) District 7. Woods at Rockingham, Roscommon; D. M. District 9. Hazlewood, Sligo; D. M. District 11. Ards woods, Donegal! M. Murphy.

Epipactis latifolia (All.) District 11. Mount Charles, Donegal; H. C. Hart.

Cephalanthera ensifolia (Rich.)—1. Wood near Lickeen House, at head of Lough Carragh; Dr. Battersby. Wood by the Kenmare road from Killarney; A. Balfe. Near Derrycunihy cascade; A. G. M.

Malaxis paludosa (Sw.) —5. Marshy places about Kelly's Glen, along

the River Dodder; Templeton.—12. Bog on Fair Head, Antrim; S. A. Stewart.

†*Sisyrhynchiun anceps* (Lam.) *S. Bermudiana* (Linn.)—6. Abundant in marshy meadows and pastures along the river on both sides, for four miles, from Woodford to Rossmore, forming conspicuous blue patches among the grass, and with every appearance of a native. Also in fields by the road from Woodford to Portumna, and on a hill half a mile N. E. from Woodford; M. Dowd, and Prof. E. P. Wright, 1870. The plant grows here in such profuse abundance that it seems hypercritical to challenge its indigenous origin; still, when we see how inexplicably it has originated, how abundant it has become within a few years, and what a strong hold it has taken of the ground at Brisbane, Queensland, as recorded by Mr. C. Prentice, in Trimen's Journal of Botany, Series 2, vol. i., p. 22 (1872); and considering that in England also it has lately become well established in Hampshire, we may well hesitate to accept the "Blue-eyed grass" of Canada as an indubitable native of Ireland. If the locality in which it occurs is nearly as restricted as that of the *S. piranthes* at Berehaven, at least the Orchid lies, like all the other American and Iberian plants, quite close to the shore, and is a species of whose introduction or rapid extension we have not any experience.

‡*Iris fœtidissima* (Linn.) A very doubtful native of Ireland, where it seems to have been formerly much cultivated, nor are we acquainted with any locality where it grows in a really natural manner.

Asparagus officinalis (Linn.)—4. Sandhills in Ballyteigue Bay, Wexford; Mr. Lewis.

‡*Allium Babingtonii* (Borr.)—6. In all three of the Islands of Aran; H. C. Hart.

A. vineale (Linn.)—3. Banks of the Nore, near Inistioge, Kilkenny; Tighe.

Simethis bicolor (Kunth).—1. Certainly indigenous at Derrynane, where it grows on boggy, heathy, and turfy slopes, far away from the Abbey ruins, amidst heather and *carices*, etc.

Eriocaulon septangulare (With.)—1. Bog-holes at north end of Lough Carragh, Kerry; Dr. Battersby. First found by Dr. Wade in 1801, as shown by a letter from him to Smith, in the Library of the Linnæan Society. In the Cloonee, not Cromeen, Lakes, Kerry.

Juncus acutus (Linn.)—1. Plentiful in the warren at Rosscarbery, and a few plants on Castlefreke sands; Rev. T. Allin.—4. At the mouth of the Kilgorman river, north of Courtown, Wexford, and on sandhills thence to Arklow; also north of Arklow in Brittas Bay, and near Mizen Head, etc., as far as Seapark House, where both it and *Equisetum Moorei* appear to cease. Flowers early in June, several weeks before *J. maritimus*.

J. obtusiflorus (Ehrh.)—1. Near Dingle, Kerry; D. M. District 8. Boggy slopes at foot of Urrisbeg Mountain, Connemara; A. G. M.

J. squarrosus (Linn.) District 10. Sperrin Mountain, Tyrone; S.

A. Stewart. Ascends to 2700 feet on Mangerton, and to 3300 on Carn Tual; A. G. M.

Luzula sylvatica (Bich.) Reaches 3400 feet on Carn Tual; A. G. M.

Butomus umbellatus (Linn.)—2. Ballycotton Bog, and abundant near Buttevant; Rev. T. Allin.—7. In the Brosna at Parsonstown; M. Dowd.

Sparganium natans (Linn. et Fries).—11. Lakes near Keel, Donegal; H. C. Hart.

S. minimum (Fries). District 7. Near Parsonstown; M. Dowd. District 10. In a lake near Drum, Clones; J. Bain.

**Acorus Calamus* (Linn.) District 12. Lakes at Hillsborough and Ballinahinch, Down, but most probably planted there; Templeton. Profusely on both sides of the Lagan, for six or seven miles between Lisburn and Moira, Down; S. A. Stewart, 1866. This is an artificial cut, and the plant does not grow in Lough Neagh, nor in the river whence the Lagan Canal is drawn. Dr. Patrick Browne, in 1788, was aware of its occurrence in the county of Down, but does not give any special locality. According to the best authorities, *Acorus Calamus* is nowhere native in the west of Europe.

Potamogeton rufescens (Schrad.)—2. Plentiful in the Blackwater at Buttevant; Rev. T. Allin. District 3. Ditch near Mountrath, Queen's County; J. Morrison.

P. polygonifolius (Pourr.) *Var.* with long, thin, narrowly-lanceolate submerged leaves; *var. pseudo-fluitans* (Syme.)—8. Plentiful in lakes and streams at Ballinahinch, Connemara; A. G. M. This is the plant doubtfully given in our book as *P. lanceolatus*, and is very characteristic of streams connected with lakes in mountainous districts. The long submerged leaves are very like those of *P. sparganiifolius.*

P. Lonchites, "Tuck" (Syme), in "English Botany." District 5. In the Boyne below Navan. By this name Doctor Syme designates the *Potamogeton* from the Boyne, which we have doubtfully referred to *P. heterophyllus.*

P. lucens (Wulf). District 7. In the Brosna, near Parsonstown; M. Dowd. *Var. decipiens* (Nolte.) District 5. In the Canal at Navan; Charles Bailey, 1868.

P. crispus (Linn.) District 11. Kindrum Lakes, Fanet; H. C. Hart.

P. gramineus (Linn.) *P. obtusifolius* (M. et K.)—2. Bogs near Youghal and Charleville, and in Ballybutler Lake, Cork; Rev. T. Allin.—10. Near Drum, Clones; J. Bain.

P. pusillus (Linn.) District 7. Common near Parsonstown; M. Dowd. District 10. Strabane Canal and Ballymagorry, Tyrone; Dr. Sigerson. District 11. Kinlough, Fanet; H. C. Hart.

P. pectinatus (Linn.) District 6. Aran Island; H. C. Hart.

Zannichellia palustris (Linn.) District 11. Glen Head, Donegal; H. C. Hart.

Naias flexilis (Rostk.)—8. In 1869, I found it only in Lough Cregduff, three-quarters of a mile west of Roundstone, and it is probable

that this is the same lake in which Prof. Oliver discovered it, and the only locality yet found in Ireland; A. G. M.

Schœnus nigricans (Linn.) District 3. Black Bog and Sandbrook near Ballon, Carlow; R. Clayton Browne.

Cladium Mariscus (R. Br.) District 3. Black Bog near Carlow, and Ardristan Bog near Tallow; R. Clayton Browne.

Eleocharis uniglumis (Link.)—4. On the sandhills near Arklow; A. G. M. District 5. On the shore east of Dollymount, opposite the North Bull, Dublin; M. Dowd. District 12. Shore half a mile below Bangor, Down; S. A. Stewart.

E. multicaulis (Sm.) District 10. Near Drum, Clones; T. Bain.

Scirpus sylvaticus (Linn.)—2. Banks of the Owley River near Kilcomer; Rev. T. Allin.—12. Deer Park, Glenarm; R. Tate.

S. lacustris (Linn.) District 3. Plentiful in the Barrow; R. Clayton Browne. District 7. Plentiful in the Brosna; M. Dowd.

S. pauciflorus (Lightf.)—5. Marshes on Howth, 1870; M. Dowd, thus confirming Mackay in Cat. Ir. Plentiful, with *Blysmus rufus*, on the North Bull, Dublin. Also on the shore east of Dollymount, and between Baldoyle and Portmarnock. Shore south of Balbriggan, with *Schœnus nigricans*; A. G. M.—9. About Ben Bulben; D. M.

Scirpus parvulus (R. et S.) District 4. Abundant at Arklow, on soft mud, overflowed at high tide on the north side of the River Ovoca; A. G. M., July, 1868 (Journal of Botany, vol. vi., 1868).

S. setaceus (Linn.) District 3. Eastern slopes of Slieve Margy, Queen's Co.; R. Clayton Browne. District 6. Aran Isles; H. C. Hart.

S. Savii (S. et M.) District 2. Plentiful near Middleton, Cork; Rev. T. Allin. District 6. Aran Isles; H. C. Hart.

Blysmus rufus (Pang.)—5. Abundant on the North Bull, opposite Dollymount; A. G. M. Flowers early in June.—12. North side of Ardglass Bay, Down; S. A. Stewart.

Eriophorum latifolium (Hoppe.) District 8. Bog on the north-west side of Urrisbeg mountain, near Roundstone, growing with *Erica mediterranea*, 1869; A. G. M.

Obs. *Eriophorum alpinum* (Linn.) Was announced in 1866, as having been gathered by Mr. Ryder on the north shore of Gurthavcha Lake, near Millstreet, county Cork (Dublin Nat. Hist. Soc. Proceedings, vol. v., p. 112), but it is now believed that some mistake was made, as the plant cannot be found in the alleged locality. (See Report of British Association, 1871, Section D, p. 129.)

Carex dioica (Linn.) District 10. By the River Derg in Tyrone; S. A. Stewart.

C. pulicaris (Linn.) District 3. Black Bog near Carlow; R. Clayton Browne. District 10. Castle Derg, Tyrone; S. A. Stewart.

C. arenaria (Linn.) District 6. Great Island of Aran; H. C. Hart.

C. divisa (Huds.)—5. Nearly extinct in the station discovered by D. M., but two large and flourishing patches were found (1871) in a damp meadow close to the Glass Works on the north bank of the Liffey; A. G. M.

C. vulpina (Linn.) District 6. In all three Isles of Aran; H. C. Hart. District 7. On margins of stony lakes near Parsonstown; M. Dowd.

C. muricata (Linn.)—2. Not rare about Middleton and Buttevant; Rev. T. Allin.—4. Fassaroe, near Bray; R. M. Barrington. District 12. Sparingly at Macedon Point, Belfast Bay, with *Hypericum hirsutum;* S. A. Stewart.

C. divulsa (Good.)—1. Muckross, Killarney; A. G. M. Near Bantry; Rev. T. Allin. District 3. Browne's Hill, Carlow; R. Clayton Browne.—5. Near Feltrim Hill; Castleknock and Celbridge; A. G. M.

C. teretiuscula (Good).—7. Plentiful in a large bog near Multyfarnham, Westmeath; D. M.—9. Bog near Clonhugh railway station; W. T. Dyer.—12. Bog at the Giant's Ring (not Causeway), county Down; D. Orr.

C. paradoxa (Willd.)—7. Nearly extinct now at Ladiston, where it grows principally along the edges of ditches, on ground recently drained. With the tufted root of *C. paniculata,* this has fruit nearer in shape to that of *C. teretiuscula,* with which Dr. Hooker has, perhaps too hastily, combined it; D. M.

C. paniculata (Linn.) District 10. Near Clones, Fermanagh (Dr. Scott), Mackay Rar. The state with a narrow unbranched panicle is not rare, and grows intermixed with the typical plant.

C. axillaris (Good). District 1. Salt marsh, near Kinsale! Isaac Carroll, 1866. This is the only locality in Ireland from which we have seen authentic specimens. *C. divulsa* has more than once been miscalled "*axillaris.*"

C. remota (Linn.) District 3. Eastern slopes of Slieve Margy, Queen's Co., and near Newtownbarry, Carlow; R. Clayton Browne.

C. rigida (Good). District 4. Top of Lugnaquillia, Wicklow; A. G. M.

C. pallescens (Lam.) District 2. Near St. Ann's, Blarney; R. Mills.—9. Near Drumod, Leitrim; W. T. Dyer.—15. Deer Park, Glenarm; R. Tate.

C. limosa (Linn.)—1. Base of Sugar-loaf Mountain, Glengarriff; Rev. T. Allin. District 2. Bluefort Bog, Newmarket; do.

C. strigosa (Huds.) District 12. Belvoir Park; Belfast Nat. Field Club Report, 1871.

C. punctata (Gaud.)—1. Plentiful in boggy or marshy meadows near Ardgroom, at some little distance from the sea; A. G. M.

C. distans (Linn.) District 6. Great Aran Island; H. C. Hart.

C. lævigata (Sm.) District 3. Ryland's Wood, near Newtownbarry, Carlow; R. Clayton Browne.

C. Pseudo-cyperus (Linn.)—2. Dunsfort Bog, Middleton; Rev. T. Allin.—4. Marshes near Newcastle, Wicklow; A. G. M.

C. filiformis (Linn.) Pool near Glengarriff; Rev. T. Allin.

C. hirta (Linn.) District 3. Sandbrook near Ballon; R. Clayton Browne.

C. vesicaria (Linn.)—2. Rather rare; but occurs near Middleton and Buttevant; Rev. T. Allin.—9. Near Drumod, Leitrim; W. T. Dyer.—10. Common in Fermanagh (Dr. Scott) Mackay Rar.

C. paludosa (Good). District 1. Caha river, Dunmanway, and District 2. Dunsfort Bog, Middleton; Rev. T. Allin. District 4. Marshes near the Murrough of Wicklow; A. G. M. District 7. Bog near Multyfarnham; A. G. M.

C. riparia (Curt.) District 7. Near Portumna; D. M. No. 5 to be added in the line of Districts.

Phalaris arundinacea (Linn.) District 3. Banks of the Barrow below Carlow; R. Clayton Browne. District 7. Parsonstown; M. Dowd.

Phleum arenarium (Linn.)—4. Sandhills at Arklow and northwards; A. G. M.—5. Gormanstown, Meath; A. G. M. District 6. Great Island of Aran; H. C. Hart.

P. pratense (Linn.) District 3. Browne's Hill, Carlow; R. Clayton Browne. District 7. Near Parsonstown; M. Dowd.

Alopecurus pratensis (Linn.) District 7. Parsonstown; M. Dowd. District 10. Enniskillen, Fermanagh; S. A. Stewart.

A. geniculatus (Linn.) District 3. In Carlow; R. Clayton Browne.

Nardus stricta (Linn.) District 3. On Mount Leinster; R. Clayton Browne. District 7. Near Parsonstown; M. Dowd. District 10. Sperrin Mountains, Tyrone; S. A. Stewart. Ascends to 3200 feet on Carn Tual; A. G. M.

Milium effusum (Linn.)—12. Dundonald Glen, and Stormont Glen, Down; S. A. Stewart.

Calamagrostis Epigejos (Roth). District 6. Between the road and the sea, near Killeany, Great Aran Island, in two places only; H. C. Hart, 1869.

C. stricta (Nutt.)—10. Scawdy Island, near Maghery, is in Tyrone, not Armagh;. S. A. Stewart. Hence, Armagh must be erased from the list of counties.—12. Shores of Lough Beg, one mile south of Church Island; R. Tate.

Agrostis canina (Linn.)—1. Ascends to nearly the top of Carn Tual, say 3400 feet; A. G. M. *Agrostis vulgaris* to 3200 feet on same mountain.

Holcus mollis (Linn.) District 3. Browne's Hill, Carlow; R. Clayton Browne.

Aira cæspitosa (Linn.)—1. A small form of this plant, which, except that the florets are not viviparous, Dr. Syme considers undistinguishable from the Scottish *A. alpina*, grows near the summit of Carn Tual; A. G. M.

A. uliginosa (Weihe). District 8. Found in July, 1869, growing plentifully on the swampy borders of Lough Creg-duff, near Roundstone; and afterwards traced by me in many localities through the district extending from Clifden to Kilkieran, Connemara; A. G. M.

Trisetum flavescens (Beauv.) District 7. Parsonstown; M. Dowd.

—12. On a dry bank in the Bog Meadows, Belfast, and by the Laggan Canal near Moira, Antrim; S. A. Stewart.

Avena pubescens (Linn.) District 7. Parsonstown, not common; M. Dowd.

Melica uniflora (Retz). District 7. Woods about Parsonstown; M. Dowd.

Poa compressa (Linn.) District 10. On the bank by roadside, half a mile from Portadown towards Lurgan! W. M'Millen. District 12. Roadside between Ballycastle and Ballintoy; D. M.

Glyceria aquatica (Sm.) District 3. In the Barrow below Carlow; R. Clayton Browne.

Sclerochloa distans (Bab.)—12. At Larne and at the upper end of Belfast Bay; S. A. Stewart.

S. Borreri (Bab.) The opinion expressed as to the possible parentage of this grass must be retracted, or, at least, qualified, since only *S. distans* and *S. maritima* grow along with it in the North Lots, Dublin.

†*S. procumbens* (Beauv.) District 12. On Albert Quay, Belfast! in small quantity, and in one place only; S. A. Stewart. This grass has not lately been gathered near Dublin, and it is believed that *S. Borreri* was mistaken for it in the metropolitan district. *S. procumbens* seems very rare, and is open to some suspicion of having been introduced both at Cork and Belfast, which are the only two Irish localities.

S. rigida (Link). District 3. Near Browne's Hill, Carlow; R. Clayton Browne. District 7. Walls and roadsides near Parsonstown; M. Dowd.—12. By the sea, two miles north of St. John's Point, Down; S. A. Stewart.

S. loliacea (Woods). District 6. In all three Isles of Aran; H. C. Hart.

Catabrosa aquatica (Presl.) District 3. In Carlow; R. Clayton Browne.

[*Cynosurus echinatus* (Linn.) Came up in a field at Sandbrook, Carlow, in 1868; R. Clayton Browne].

Festuca uniglumis (Sol.) District 4. Sandhills from Courtown to Arklow, and northwards to Rockfield, Wicklow; A. G. M.

Festuca sciuroides (Roth). District 7. Walls at Parsonstown, but rare; M. Dowd.

F. Myurus (Linn.) District 1. Walls at Dingle and Milltown, Kerry; A. G. M.—2. Common at Avoncore, and occurs in both East and West Cork; Rev. T. Allin. District 4. Springhill, Enniscorthy! J. Morrison. Walls at Arklow and Wicklow; A. G. M. District 6. Near Ballyvaughan, Clare; Rev. T. Allin. Probably not unfrequent in the middle and south of Ireland.

F. arundinacea (Schreb.) District 7. Banks of the Brosna and other places near Parsonstown; M. Dowd.

Bromus erectus (Huds.) District 3. Railway banks near Portarlington, etc., towards Cork, extending probably to District 7; A. G. M. District 4. Banks on north side of Bray Head; A. G. M.

Triticum pungens (Pers.) Districts 4 and 5. Frequent on the Mur-

rough of Wicklow, and on banks and along ditches on the coast of probably all Ireland. A large form found on the shore near Rush has for many years been cultivated in the Botanic Gardens, Glasnevin, under the name of "T. Moorei."

‡*Lolium temulentum* (Linn.) District 10. In Tyrone; Dr. Sigerson.

Hordeum pratense (Huds.) District 6. Meadows near Limerick; I. Carroll.

Equisetum hyemale (Linn.) District 6. At Lough Atalia in the Great Island of Aran; H. C. Hart. District 10. Banks of the Colebrooke river, Fermanagh; T. O. Smith. District 11. Little Bins, Fanet; H. C. Hart. The plant of the Dundrum sandhills probably should be referred to "E. Moorei."

E. Moorei (Newman, 1853). Milde, the highest recent authority, places this plant under *E. hyemale* as *var. Schleicheri* (Milde, 1858); but, as already observed in Seemann's "Journal of Botany," vol. vi., *E. Moorei* is the older name, and should be retained, in preference also to *var. paleaceum* Schleicher, adopted by Dr. Hooker in the "Student's Flora," but which has been rejected by Milde as ambiguous.—4. Sandhills north of Courtown, Wexford. Sandhills near Arklow, and thence northwards in many places along the coast extending to near Seapark House, three miles South of Wicklow.

E. trachyodon (A. Braun). *E. Mackaii* (Newman). District 2. Near St. Ann's, Blarney! (R. Mills); Rev. T. Allin, 1871. This will extend the range to South of Ireland.

E. Wilsoni (Newman). District 7. Canal near Mullingar; R. W. Rawson. District 8. Shores of Lough Bulard, near Roundstone; A. G. M. District 9? Shore of Lough Carra, Mayo; J. Ball. Probably this, rather than *E. trachyodon.*

Polypodium Phegopteris (Linn.) District 2. Rocks above Gurthaveha Lake, near Millstreet, with *Asplenium viride;* A. G. M.—8. Abundant in Glan, south of Maam Bay, Lough Corrib, Galway, and in the Coomb, south-west of Dromin Chapel, Mayo; G. H. Kinahan.—10. Deer Park, Brookboro'; Rev. S. A. Brenan.

P. Dryopteris (Linn.)—9. Near Lough Talt! on the Ox Mountains, Sligo; R. Warren.

Lastrea Thelypteris (Presl). District 4. Marshes in Glencree; Mackay, Cat. Ir.—5. At Lullybeg between Robertstown and Rathangan, in Kildare; Mrs. Cooke Trench. Drumconrath, Meath; Rev. S. A. Brenan.—7. Rockingham, Roscommon; D. M.—10. Near Caledon, Armagh; E. Wallis.

L. Oreopteris (Presl). District 3. Abundant at foot of Mount Leinster, and on the banks of the Upper Barrow; R. Clayton Browne.

Polystichum aculeatum (Roth). District 3. At Browne's Hill and other places in Carlow, but rare; R. Clayton Browne.

Cystopteris fragilis (Bernh.)—2. Rocks above Gurthaveha Lake, near Millstreet; A. G. M. Dunmore East, Waterford; H. Fitzsimons. District 3. A single plant at Pollerton, near Carlow, R. Clayton Browne.—5. On the bridge at Monasterevan; Mrs. Cooke Trench.

Asplenium lanceolatum (Huds.)—1. On an old tower at Reencahirne and on Ballycarbery Castle, near Caherciveen; Rev. S. Madden.

A. Adiantum-nigrum (Linn.); *var. acutum* (Bory.)—1. By the River Shannon, near Corgrig, Foynes! Miss C. G. O'Brien. District 8. Frequent in Connemara and south-west Mayo; G. H. Kinahan.

A. viride (Huds.)—2. Rocks above Gurthaveha Lake, near Millstreet; A. G. M.—8. Lissoughter, Glenlosh, and Bengower, Galway, and south-west of Dromin Chapel, Mayo; G. H. Kinahan.—11. In a gully on the north side of Slieve League! H. W. D. Dunlop.

Adiantum Capillus-Veneris (Linn.)—1. Sea-wall under Mount Trenchard, near Foynes; Rev. L. O'Brien.—8. Hill north-north-east of Sheffey, five miles from Killery Harbour; G. H. Kinahan. District 11. In one place on the cliffs of Slieve League (found by Rev. L. O'Brien); Rev. R. J. Gabbett.

Hymenophyllum tunbrigense (Sm.) District 10. In a glen between Aughnacloy and Augher, Tyrone; E. Waller. On the mountains near Florencecourt, with *H. Wilsoni;* Rev. S. A. Brenan.

H. Wilsoni (Hook.) District 3. On Mount Leinster; R. Clayton Browne.

Ophioglossum vulgatum (Linn.) District 11. Fanet and by Lough Swilly; H. C. Hart.

Isoetes lacustris (Linn.) District 2. In Gurthaveha Lake, near Millstreet; A. G. M.—4. A long slender form, some of whose fronds measured 26 inches, is in autumn washed ashore from deep water at Upper Lough Bray. Milde gives this Lake as a station for *I. echinospora*, which, however, I have not succeeded in finding there; A. G. M. In Lough Luggelaw; D. Orr.

Lycopodium clavatum (Linn.) District 3. On Mount Leinster; R. Clayton Browne.—10. On the mountains of Mourne; Harris's "Down," No. 19.

L. Selago (Linn.) District 3. Near Mount Leinster; R. Clayton Browne.

L. selaginoides (Linn.) District 3. Black Bog, near Carlow; R. Clayton Browne.

LIST OF PAPERS RELATING TO THE FLORA OF IRELAND, PUBLISHED FROM 1865 TO 1872.

Andrews, W. On some Irish Saxifrages. Dublin Nat. Hist. Soc. Proceedings, vi., p. 84 (1871).

Allin, Rev. T. Irish Plants. Seemann's Journal of Botany, ix., p. 18 (1871).

—— Plants of County Cork. Seemann's Journal of Botany, ix., pp. 111 and 173 (1871).

Barrington, R. M. On some plants recorded from Ireland. Trimen's Journal of Botany, i., p. 108 (1872).

Dowd, M. *Malva borealis*, near Dublin. Seemann's Journal of Botany, viii., p. 323 (1870).

Foot, F. J. *Hymenophyllum Wilsoni*, near Boyle, etc. Dublin Natural History Society Proceedings, v., p. 66 (1865-6).

Kinahan, G. H. On Ferns observed in West Connaught and Southwest Mayo. Dublin Natural History Society Proceedings, vi., p. 67 (1871).

Moore, D., Ph. D. *Eriophorum alpinum*, and *Acorus Calamus*, found in Ireland. Dublin Natural History Society Proceedings, v., p. 112 (1866-7), and Seemann's Journal of Botany, v., p. 46 (1867).

—— *Trifolium glomeratum* in Ireland. Seemann's Journal of Botany, viii., p. 192 (1870).

—— On a form of *Salix Arbuscula* (afterwards corrected to *S. Grahami*, ix., p. 300), in Ireland. Seemann's Journal of Botany, viii., p. 209 (1870).

—— Notes on some Irish Plants. Seemann's Journal of Botany, ix., p. 299 (1871).

D. Moore and A. G. More. On the Climate, Flora, and Crops of Ireland. International Botanical Congress Report, 1866.

More, A. G. *Trifolium subterraneum* in Ireland. Seemann's Journal of Botany, vi., p. 208 (1868).

—— Note on *Equisetum Moorei*, etc. Seemann's Journal of Botany, vi., p. 253 (1868).

—— *Hippophae rhamnoides* in Ireland. Seemann's Journal of Botany, vi., pp. 255 and 373 (1868).

—— Discovery of *Scirpus parvulus* in Ireland. Seemann's Journal of Botany, vi., pp. 254 and 321 (1868).

—— Discovery of *Aira uliginosa* at Roundstone. Seemann's Journal of Botany, vii., p. 265 (1869.)

—— On *Eriophorum alpinum* as a British Plant. British Association Report, 1872.

Sigerson, G., M. D. Additions to the Flora of the tenth Botanical District, Ireland. Royal Irish Academy Proceedings, Sec. Ser., vol. ii., Science, p. 192 (1872).

Smith, W. G. Discovery of *Cuscuta Trifolii* in Ireland. Dublin Natural History Society Proceedings, v., p. 198 (1868–9).

Stewart, S. A. On some rare or overlooked plants in the neighbourhood of Belfast. Belfast Naturalist's Field Club Proceedings, (1865–6).

—— A Run through Galway with a Vasculum. Belfast Nat. Field Club Proceedings (1867-8).

—— A Visit to Dungiven and the Sperrin Mountains. Belfast Nat. Field Club Proceedings (1868-9).

Tate, R. The Flora of Ireland, with special reference to Ulster. Belfast Nat. Field Club Proceedings (1866-7).

—— Addenda to the "Cybele Hibernica." Seemann's Journal of Botany, viii., p. 81 (1870).

Wright, Professor E. P. Notes on the Flora of the Islands of Arran. Dublin Natural History Society Proceedings, v., p. 96 (1866-7).

Supplementary List of Papers, etc., published previous to 1866.

Andrews, W. Botanical Excursion in Clare and Kerry. Dublin Natural History Proceedings, reported in Annals of Natural History, vi., p. 382 (1841).

Babington, Professor, C. C. On the recent additions to the Flora of Ireland. Annals of Natural History, vi., p. 328 (1841).

Gage, Miss C. Plants of Rathlin Island. Botanical Society, Edin. Proceedings reported in Annals of Natural History, Sec. Ser., v., p. 145 (1850).

Harris, Walter. The Ancient and Present state of the County of Down, 1744. Chap. xi. contains a catalogue of forty rare plants which was probably contributed by Isaac Butler.

Harte, W. On the Occurrence and Geological Relations of certain Ferns in the County of Donegal. Dublin Natural History Society Proceedings, iv., p. 247 (1865).

Harvey, Professor W. H. On a new British Saxifrage (*S. Andrewsii*). London Journal of Botany, vii., p. 571 (1848).

Hincks, Rev. T. D. On Early Contributions to the Flora of Ireland. Annals of Natural History, vi., pp. 1 and 126 (1841).

Lambert, A. B. Anecdotes of Patrick Browne. Linnæan Society Transactions, iv., p. 33 (1798).

Moore, D. Botany of Parish of Templemore, in Ordnance Survey of the County of Londonderry, pp. 9–11; and pp. 6–8, plates 4, 5, of "Notices" (1837).

Sampson, Rev. G. V. Memoir explanatory of the Chart and Survey of Londonderry. List of Plants, pp. 152–171 (1814).

Sim, John. Remarks on the Flora of Ireland. Phytologist, 2nd Series, iii., p. 353 (1859). Cf. Natural History Review, vii., p. 434 (1860).

Templeton, John. On a New Species of Rose (*R. Hibernica*, Smith, 1810). Royal Dublin Society Transactions, iii., p. 162, with plate (1802).

Thompson, W. *Galium cruciatum*, an Irish plant. Annals of Natural History, ix., p. 519 (1842).

Tighe, W. Statistical Observations relating to the County of Kilkenny (1802). List of Plants (including *Calamintha Acinos*), pp. 207 and 359.

—— Plants of Coast of Wexford. Royal Dublin Society Transactions, vol., iii., p. 147 (1802).

Note.—According to information lately received, it seems that *Plantago media* has some claims to be considered naturalized in the locality where Mr. Douglas observed it, and which he describes as not far from Malone's Gravel Pit, to the north of Straffan, where the plant formed quite a carpet, and the pink anthers were very conspicuous.

XXXIII.—On a new Form of Goniometer. By Joseph P. O'Reilly, C. E., Professor of Mining and Mineralogy, Royal College of Science. With Plate XX. (Science).

[Read June 24th, 1872].

The principle involved in the construction of the Goniometer now submitted to the Academy, applies rather to instruments intended for the measurement of angles in general, than to those which are specially destined to the measurement of the angles of crystals. This principle is, the substitution of a straight edge or divided scale in the determination of angular measurements, for the divided circle usually employed. Now as a straight edge can be more easily and more accurately divided than a circular one, and as length of edge is, in this case, the sole condition as regards dimension, requisite for the attainment of measuring power, it is evident that such a substitution must at once both simplify and cheapen the instrument, while the bulk being considerably reduced, and the form rendered very convenient, the instrument can be rendered quite portable and safe for the purposes of the field Geologist and Mineralogist. This new form may therefore be considered as pretending to simplicity, reduced bulk, and accuracy, and consequently to cheapness and usefulness. Those latter considerations are most important from the point of view of education. Students, as a rule, are not sufficiently well acquainted with the different instruments brought under their notice in scientific lectures, nor can they well become acquainted with many of them on account of their costliness, bulk, and delicacy of arrangement; but with even the more ordinary instruments, there is generally wanting that degree of familiarity which induces the use of them for observation, and that knowledge of their relative degrees of utility, which is really the fundamental point of all sound observation. To cheapen an instrument is therefore to put it more generally within the reach of students. To simplify it without lessening its accuracy is to encourage them to a more frequent use of it, and thus really to induce them to study science in a practical manner. Such was my principal object in attempting to improve on the ordinary Wollaston Goniometer. For cabinet-work no instrument can be more perfect than this, and few have rendered greater services in their way. But its bulk renders it unsuited for the purposes of the field student, while it is really in field work that the easy and rapid determination of the special characteristics of minerals becomes of great value; and of those none can be more important as far as regards crystalline minerals, than the determination of the angles. Is it possible to attain the results given by the Wollaston Goniometer by means of an instrument equally precise, but much more simple, and more reduced in bulk? Such was really the problem which I undertook to solve. Now whatever may be the form of the instrument to be employed, there must be necessarily an axis of rotation on which to adapt the crystal requiring measure-

ment; and there must necessarily be an arrangement allowing of the proper placing of the crystal edge for measurement. The method by which this is attained in the Wollaston Goniometer is so simple and so perfect that it becomes indispensable. The method of placing the edge of the crystal in the axis of the instrument varies, but all the arrangements employed resolve themselves into attaching the crystal, by a piece of wax, to a moveable piece which is rendered capable of movement in different directions, or planes, so that the desired position of the edge may be accurately attained. In the present instrument, those arrangements have been suppressed, for a very simple reason, that the intermediary of wax being in all cases requisite for attaching the crystal, it is much more simple for the observer or student to use his manipulative skill, in attaching it, so that he may insure all the conditions necessary for correct measurement; and a proper disposal of the piece of wax employed can always allow of this result being practically attained. There would, therefore, necessarily remain, as fundamental part of the instrument, the cylindrical axis carrying the crystal, moveable in a sheath, or exterior cylinder carrying the divided scale, whether straight or circular.

Now if we suppose, traced on the cylindrical axis carrying the crystal, a spiral or screw of any given pitch, and if we suppose this axis to turn within a cylindrical sheath of at least the length of half the pitch of the screw, and that, moreover, the exterior cylinder be cut away so as to form a slit in its surface parallel to the axis of the instrument, and of the length of the half pitch, it is clear that the spiral traced on the axis must cut the edges of the slit, at distances from either extremity of it, proportional to the angle through which the axis shall have been turned. It is equally evident that a divided scale carrying 90 or 180 division will give, for a half revolution, measurements in double or single degrees of this angle. In fact, the divided circle of the Wollaston Goniometer is replaced by a spiral on the axis. Now this method of measurement is independent of the diameter of this cylindrical axis, and depends entirely for accuracy on its length. We have thus the means of reducing considerably the bulk of the instrument, while, by taking, as units of division on the straight edge of the slit, half millimetres, or millimetres, which can thus most conveniently be introduced, we can have the measuring part of the instrument reduced to a length of 180 millimetres at most, and practically to 9 millimetres; measuring to single degrees, if the half millimetre be taken as unit, or to double degrees if the millimetre. The whole instrument may thus have a length not exceeding 25 centimetres, and reducible to about 15, while the greatest diameter may not be more than 15 millimetres, and I believe, can be reduced to 10 millimetres by nice construction. The form of the instrument would even allow of a greater length without rendering it at all inconvenient, or unsafe for carriage.

It remains to show that accuracy is no way lost, at the expense of compactness; in other words, that the vernier arrangement is both simple and effective. The exact determination of the coincidence of

the spiral with the divided scale is attained by means of a triangular piece, which slides along the slit, and one edge of which is cut according to the same spiral as that traced on the cylinder or axis. It is thus easy to bring this edge to coincide with the portion of the spiral showing itself between the two edges of the slit; a line traced transversely on this slide-piece, at the base of the triangle, indicates the point of coincidence of the spiral with the divided edge, and therefore shows the corresponding number of degrees, while the opposite side of the slide-piece carries the vernier giving the fraction of degree.

I have not introduced any tangential screw, as practically unnecessary, and tending to complicate the instrument; nor have I made any special arrangement for setting up the instrument in a fixed position, on a stand, as I would prefer leaving that to the skill, and practical ingenuity of the student; it being precisely one of those simple mechanical problems which chemists have frequently to solve, and which may be solved in many simple and sufficient ways. The essential portions of the instrument existing, any further addition must increase its bulk, render it more costly, and in no way add to its accuracy.

DESCRIPTION OF PLATE XX.

a. Crystal.

b. Wax attaching crystal to moveable cap C. C., fixed upon the inner revolving axis.

c. d. Screw Cup retaining the outer revolving axis in cylindrical cover.

d. d. Runner carrying the vernier k. k.

f. Head by which the outer revolving axis is turned by hand, so as to give measurement.

g. Head of inner revolving axis, allowing of proper disposal of crystal for measurement.

k. k. Vernier.

h. h. Slit in cylindrical cover, and having the opposite edges divided.

m. m. Spiral traced on outer revolving axis, as seen in contact with edges of slit.

XXXIV.—Notice of the Genus Tetrapedia (Reinsch), and of two kindred new Forms. By William Archer.

[Read June 24, 1872.]

Amongst "Unicellular" Algæ (as well in the wider as in the most strict sense), falling under the class Chlorophyllaceæ, forms with specially figured cells—that is, otherwise than globular, ellipsoidal, or cylindrical, with more or less abruptly or broadly rounded ends—are, as is well known, numerous. One has only to call to mind, not to

speak of almost the entire family of Desmidieæ, such forms as those appertaining to the genera Polyedrium (Näg.), Scenedesmus (Meyen), Pediastrum (Meyen), Ophiocytium (Näg.), Cœlastrum (Näg.), Characium (Al. Braun), Dimorphococcus (Al. Braun), &c., for examples of very varied and at same time seemingly characteristic outlines.

But amongst unicellular plants belonging to the class Phycochromaceæ, so frequently found in the same situations associated with the foregoing, as well as with other less prominently marked chlorophyllaceous types, not until recently, so far as I am aware, has attention been drawn to any examples of a specially figured outline—that is, as mentioned, in shape otherwise than globular, ellipsoidal or cylindrical.

I need hardly contend, indeed, that the "figure-of-8-shape," assumed by many such during the progress of self-division, cannot be regarded as an exception, or as in itself special. Thus, in the genus Synechococcus (Näg.), for instance, the ordinary oblong subcylindrical cell becomes transversely constricted during growth, so as to assume a "figure-of-8-shape;" but the two segments having attained their full size, the constriction is simultaneously carried through and through, separation ensues, and the oblong sub-cylindrical figure in each new cell is resumed.

Possibly, indeed, the departure from the so frequent ellipsoidal type, which is shown by the cuneate or rather obovate cells of *Gomphosphæria aponina* (Kützing), may, so far as it goes, indicate a certain amount of approach to a special figure, enhanced, too, as it might appear to be, by the very pretty obcordate shape presented by the cells during division. Indeed, a doubly-obcordate figure is not unfrequently seen; that is, when the division proceeding vertically from above downwards, being partially advanced, is quickly succeeded by a second line of division setting in at right-angles to the former, also proceeding vertically from above downwards—then the shape assumed presents an obcordate outline on each of its four vertical aspects, and, when viewed from above, or somewhat obliquely, is seen to be four-lobed. A cell in such a progressive stage of division is thus somewhat comparable to the figure of a four-lobed Euonymus fruit. (This allusion, of course, is only to assist in conveying a conception of the shape presented). But, when the self-division is complete, the cuneate or obovate figure is resumed. Indeed, even the regular tapering off towards the lower or inner extremity of the cells may be possibly held to be but a consequence of their mutually approximate radial disposition, occurring, as they do, embedded in the substance of the ends of a number of radially projected dichotomously subdivided *arms* of rather firm gelatinous matter, emanating in a somewhat stellate though quite irregular manner from a common centre, the whole surrounded by a more or less conspicuous gelatinous envelope, and forming an unequally rounded globose family. Gomphosphæria thus would seem to form, to a certain extent, a parallel amongst Chroococcaceæ (Phycochromaceæ) to Oocardium amongst Palmellaceæ (Chlorophyllaceæ).

It does not appear, then, until the genus Tetrapedia was founded

by Professor Reinsch,* for two new and singular exceedingly minute Chroococcaceous forms, that examples of specially figured cells were known in this family of Algæ. Here we have unicellular Chroococcaceous plants existing quite free and unattached, and, therefore, in no way acted upon by mutual pressure, or capable of being modified in outline by any mechanical exigency of position of growth, and at same time offering very characteristic and even complex figures. Inasmuch, therefore, as I apprehend Professor Reinsch's work must be but little known in this country, and as the specialities of his forms seem not yet clear, upon which, possibly, observers with us, should they encounter them, might be able to assist in throwing light—and, further, inasmuch as I am myself acquainted with two other figured, but less complex, also very minute forms, clearly of similar nature, though not absolutely fitting into the genus, as characterised by Reinsch—for these reasons it has appeared to me that a notice thereof might find a fitting place in these pages, accompanied by a reproduction of Reinsch's, as well as by a sketch of my own forms (Pl. XXI.), and (although no further light can be shed upon them than that "there they are") become, at same time, a not wholly unwelcome contribution to English readers.

Perhaps, before endeavouring to convey an idea of my two less striking but new forms, it would be best to reproduce Reinsch's Latin description of his genus, and of his two forms falling thereunder, examples of one of which I have also once myself met with in a gathering made in County Westmeath. It is as follows :—

Class, *Phycochromaceæ.*
Family, *Chroococcaceæ.*
Genus, *Tetrapedia* (Reinsch).

Cellulæ solitariæ aut rarius consociatione individuorum plurium familias ex cellulis binis, quaternis aut 16is exstitutas constituentes, in sciagraphia quadraticæ, cellula singula incisuris quaternis in cellulas filias quaternas dilapsa, cellulæ filiæ post divisionem individuas singulas se præbentes, incisurarum directio in marginum lateralium directione perpendiculari aut in angulo semirectangulo versa; cellularum interanea granulosa, colore æruginco.

Tetrapedia gothica. P. Reinsch.

Cellulæ in sciagraphia quadraticæ, margines laterales in medio non profunde incisi, lobuli in medio paulo emarginati; cellulæ evolutiores quadripartitæ, incisurarum directio in marginum lateralium directione perpendicularis. (Pl. XXI., figs. 1 to 7).

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* "Die Algenflora des mittleren Theiles von Franken," by Professor Paul Reinsch, Nürnberg, 1867, p. 37, t. II., fig. I., and t. I., fig. VI. Also in the author's Memoir "De speciebus generibusque nonnullis novis ex Algarum et Fungorum Classe" (1867, p. 30, t. I, fig. A I.; ex vol. VI. "Act. Societ. Senckenb.").

Latit. 0.006 mm. usque 0.008 mm.; familiæ ex quaternis cellulis extructæ latit. 0.013 mm.; familiæ ex cellulis 16 is extructæ latit. 0.027 mm. usque 0.03 mm.

Tetrapedia Crux Michaeli. P. Reinsch.

Cellulæ in sciagraphia quadraticæ, margines laterales integerrimi utrimque leniter emarginati; cellulæ evolutiores (in statu divisionis) quadripartitæ, incisurarum directio in marginum lateralium directione angulo semirectangulo versa. (Figs. 9 to 10).

Cellularum (in statu divisionis) latitudo 0.008 mm. usque 0.012 mm.

The first species (*T. gothica*), I have never had the good fortune to encounter, and would, indeed, be extremely glad to have an opportunity to examine so remarkable a unicellular growth. As is seen from the figure (Pl. XXI.), a young cell in *T. gothica* is compressed, quadrate, slightly emarginate at the middle of each lateral margin, the angles rounded, a slight marginal concavity between each of the four central emarginations and each of the four angles (figs. 1, 2); side-view oblong, concave at the middle at each side, end broadly rounded (fig. 7). By-and-by, as would appear, the cell becomes more and more deeply incised at all the four sides, the incisions, taking origin equi-distantly from the angles—that is to say, from each of the four lateral emarginations, of which, indeed, these are but the initiations—proceed in a direction perpendicular to the sides, until they *almost* reach the centre (figs. 4, 5). The cell is now cut very nearly into four quadrate quarters, but these remain still mutually attached by a narrow connecting portion, and, of course, this forms a bond of union, and must maintain a passage of intercommunication between the cavities of the four quadrate sections; this, at least, is very plainly conveyed by Reinsch's figure. *Pari passu* with the progress of these lateral and vertical incisions, a growth or increase of dimensions, so far as we can judge, seems to occur, and each of the four quadrate sections, when the incisions have progressed to this extent, appears to be about equal in size to the original single quadrate cell. The line of incision does not appear to be simply rectilineal and acute below, but it leaves a somewhat considerable interval between the segments, and at the lower or inner extremity it is bluntly rounded, and higher up it offers a somewhat undulate appearance, whilst the general or average breadth of the incision is pretty much alike throughout. This undulate outline is due to the circumstance that each of the four margins of the four segments, the two inner of each, as well as the two outer, at this stage possesses a minute emargination at the centre, the two *new* angles (or those at the top or outer extremity of the incisions) being rounded off similarly to the single *old* angle of each (or those forming the four angles of the primary quadrate cell). As in a single cell the intervals between the central emarginations and the angles offer a slight marginal concavity; the remaining angles of each of the four segments are, of course,

those by which they remain mutually connected. In fact, we have now presented a cell with four quadrate segments, mutually bonded together by the inner angles, the whole as yet forming but one common cavity, each of these four segments, except as to their being so united by one of their angles, offering all the same characteristics as the original single quadrate cell (fig. 4). A further degree of complexity seems now to arise. Taking origin from each of the emarginations at the centre of each of the sides of all the four quadrate segments, into which the original cell has become subdivided (as well from those bounded by the lines of incision as those external), a secondary incision takes place, proceeding likewise in a direction perpendicular to the sides, and progressing until each of these too almost reaches the centre. Like the incisions of the primary cell, they also are somewhat wide, rounded below, and with a somewhat undulate outline, due to precisely the same circumstance, that at the middle of all the sides of each and every of the new quadrate segments (the inner as well as outer), a minute emargination presents itself, and the angles being rounded, with a slight concavity between these and the central emargination. *Pari passu* with the formation of these further incisions of each of the now new quadrate *segments of the segments* of the original quadrate cell, they, too, in their turn become increased in size, so as to equal their predecessors, as these equalled the original cell, whilst they, likewise, remain bonded together by the inner angles, the incisions not proceeding so far as to effect a complete separation. There is thus now a highly complex form produced: sixteen quadrate segments have resulted from the formation of the primary and secondary sets of incisions, and these are combined into one *tablet* by five points of mutual union; that is to say, the single median point of union of the group of four primary segments, the result of the first segmentation of the original quadrate cell, and the four points of union of *four sets* of four segments of the primary segments, now having each attained the original dimensions. The original quadrate cell has now become a quadrate tablet of sixteen times its superficial dimensions, composed of sixteen compartments, divided off by deep incisions, three from each side of the *tablet;* each of those proceeding from the middle of each side to the centre, is, of course, cruciform, whilst the two others, reaching only to the point of union of each of the secondary sets of segments, are simple; but all the cavities of all the compartments of the tablet maintain, of course, a common intercommunication at the before-mentioned five points of junction (fig. 6.) Such an example, indeed, as this calls to mind a *door-key* of many *wards*, if so homely an illustration be allowable.

Nor does this appear to be all: judging form Reinsch's figures* (see our figures 5 and 6, after Reinsch), and from just a single mention made in his explanation of the plate, a further apparently singular characteristic appertains to this most curiously complex form. It would appear

* *Op. cit.* t. ii. fig. 1., k. m.

that even at a comparatively early period of the progress of growth of this form, that, is, in examples with only four primary incisions, a foramen or aperture—an indubitable *hole* ("Loch")—exists right through and through the cell at the very centre of the common point of union of the segments, or in a sixteen-segmented tablet five such *holes* may present themselves. These foramina are square, or rather the sides of the short *tube* thus formed are somewhat convex inwardly, and thus the angles acute. In one of Reinsch's figures (fig. 5) this opening is delineated with its *angles* towards the ends of the incisions, and in another (of a sixteen-segmented tablet, fig. 6), the *sides* of the opening are shown as towards the ends of the incisions (the author does not himself refer to this difference). To judge from Reinsch's figures, these *holes* seem very remarkable; they are not holes in one side of the cell-wall, which, as we know, can sometimes occur, as in cells of Sphagnum-leaf, the openings in the oogonia of Œdogonium, &c., &c., but they are holes, bored as it were, clean through both walls, the membrane from both sides lining them, thus making a free passage through the thickness of the cell. They are not, if we judge Reinsch's figure aright, comparable to the openings in the "cœnobium" of a Cœlastrum, or a Pediastrum, or of Gonium, &c., which are the spaces between the component individualized cells of a stratum, but here it would appear that even the tablet, shown in fig. 6, is still only *one cell*, with sixteen compartments, *nearly*, but not quite, shut off from one another, and therefore still in mutual intercommunication. Repeatedly *vertically quadripartite* is thus the main feature of this form.

One of Reinsch's figures seems to offer a deviation from the general description here sought to be conveyed (fig. 8). Four apparently distinct cells are closely juxtaposed, the individual cells (instead of quadrate, the angles rectangular, but, as mentioned, rounded off), are here equally four-lobed, the lobes semicircular and entire. Thus, between the four lobes occur four sinuses, these acute-angled at the deepest point. In the centre, between the whole four cells, there occurs an acutely-quadrangular hollow-sided vacant interval of equivalent length and breadth, and between each pair of the four-lobed cells also an acutely-quadrangular hollow-sided vacant interval, longer than broad, the longer diameter of these four interspaces running in the direction of the angles of the equally quadrate central vacant interval—the form and direction of these (*five*) interspaces being, of course, simply due to the semicircular outlines of the lobes of the juxtaposed cells. One can, in fact, exactly reproduce the *outline* presented by the form in question, and even bring out the whole of the characteristics of the *contour* of fig. 8, by placing sixteen similar *coins* in four groups of four each, the coins so much overlapping one another as to allow, as nearly as possible, just one half the circumference of each to remain uncovered. Of this form Reinsch has seen but a single specimen, and, referring to it as he does only in the description of the plate, is disposed to take it for a distinct plant.

Such (with this aberrant, or more likely quite distinct form) is this

interesting chroococcoid, *T. gothica* (Reinsch), so far as we are able to gather from the material afforded. The question is, what is its mature state? Do any portions, more densely filled with contents become shut off, as resting-cells or "spores" (such as in Anabaina)? What limit is there to this subdivision? Figure 6, with its sixteen quadrate segments, offers at all the sides of all the segments the same minute central emargination, as in the earlier conditions, indicative (?) of a further formation of similar incisions, which, if carried out to the same extent, would result in each of the sixteen segments being cut into four further (tertiary) segments—such a tablet as fig. 6 represents, would then become one of sixty-four segments of four times the superficial dimensions of the former. Do the segments, at some epoch, and what, become cut through, and such as figs. 1 or 2 result? The words of Reinsch's description convey that this takes place, though he has nothing afterwards explanatory as to the point. Are the *holes* a constant characteristic? or can they point to an impending dislocation or disuniting of the segments, thus initiated, in a singular manner, it is true, at a new place of origin, instead of by a carrying onwards of the vertical incisions? The foramen or *hole*, shown in fig. 5, resembles the central *interspace* of fig. 8, owing to the direction of its angles, but the holes in the compound tablet, shown in fig. 6, as before drawn attention to, have the angles in the reverse direction. They are depicted as, and denominated *holes*, by Reinsch: may they be, after all, but interspaces, and the segments distinct cells, cohering at the adjacent angles by a gelatinous *cushion* (not united by a narrow isthmus of the cell itself, this afterwards perforated), and thus the opening amounting to no more than a break in the temporarily *cementing* medium? But if, as we must infer as yet, they are truly openings formed in the "cell" itself, they do not seem to present themselves for some time, apparently at least until the primary incisions are advanced; and the question arises as to *how* they first originate?

Nor, indeed, are queries similar to those suggesting themselves, touching *T. gothica*, apparently at all more capable of receiving satisfactory replies, as regards any of the three other forms, constituting with it the subject of the present communication. The second form referred to this genus by Reinsch, *Tetrapedia Crux-Michaeli*, is (like the preceding) very minute, compressed, quadrate, the lateral margins entire, and, in all the examples noticed, with two shallow sinuses or concavities extending from the middle point of each side on to the angles, thus producing an obtuse-angled central protuberance, the margin at all the four angles deeply and obliquely incised, the incisions reaching to nearly two-fifths of the diagonal diameter of the cell, their sides rectilineal, acute at the inner extremity, slightly widening upwards (fig .9). The incisions thus bisect the right angles of the quadrate cell, and subdivide it into four broadly cuneate segments, the outer angles of which are sub-acute, and with the two gentle sinuses, as before referred to, occupying the whole of the outer margin. The

edge or side-view of the cell presents a lanceolate outline, the extremities acute (fig. 10).

The quadripartite condition is regarded by Reinsch as a "state of division;" but he does not figure or refer to the simple or undivided state: it is not clear, indeed, how the carrying onwards of the incisions to completion, even until it should involve entire separation of the segments, would result in the formation of a secondary set of *quadrate* cells, like the assumed young form—if pushed through and through the quadrate cell would simply become cut into four triangular ones—two sides straight and one with the two sinuses.

One might suggestively, however, put the following possibility. Assuming the incisions carried on till four distinct younger cells were produced, of course of the triangular figure, they each would be equal to one-fourth the superficial dimensions of the original cell, and they would *resemble* a moiety of a similar cell of one-half its superficial dimensions, and, *as if* separated from its assumed fellow *diagonally*. Now, we might suppose each of them capable of growing a new half of triangular form, the obtuse-angled prominence taking the place, as it were, of a kind of *punctum vegetationis*, that is (so to say), *as if* the cell were stretched or pulled by some force to double its size, the little prominence always remaining the apex, until a quadrate figure were attained; it would, of course, likewise be requisite to suppose a general increase in size of the whole cell thereupon, or *pari passu;* they occur, however, of varying sizes. It would further be necessary to suppose a new incision to originate at each angle, and the central protuberance to be developed at each side, producing the two sinuses. Were all this accomplished in each of the separated cuneate segments, four new similar cells to that figured would be the result. This, however, is but quite conjectural, and it seems to remain quite uncertain as to how the cells grow and divide into new cells. The few examples I have seen were similar to those figured, that is, deeply incised with the four broadly cuneate segments, the specimens slightly differing in dimensions, and showed no tendency to any further alteration. There is a certain amount of possibility of this form being taken for a minute Pediastrum (Meyen); but apart from the *colour* of the contents, there is no Pediastrum with similar outline of the cells, and, indeed, as regards the examples hitherto seen, the common union of the segments at their bases prevents any confounding with a Pediastrum, which is composed of distinct but closely juxtaposed cells, held together as a frond or "cœnobium" by a kind of hyaline "intercellular substance." *Obliquely quadripartite* is thus the great feature of this form.

Not less problematic, on all points, is the third form (figs. 11, 12). I would draw attention to one, which, so far as I can learn, has not hitherto met observation;* it is clearly, however, one of kindred nature

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* During the interval that the above Paper was in the hands of the printer, I enjoyed the great gratification and valued privilege of making the personal acquaintance of Dr. Veit B. Wittrock, of the University of Upsala, on the occasion of a (too

to the foregoing. The most ready manner to convey an idea of the figure of this also very minute form is, to say it *resembles* that of an Arthrodesmus; in other words, it is compressed, quadrangular, divided by two opposite, deep, wide, triangular notches into two broad cuneate segments, their lower (or inner) sides slightly convex, and the outer angle subacute, and very minutely apiculate, and the upper (or outer) sides *very slightly* concave at the middle, somewhat raised towards the angles,* the contents pale æruginous colour, and homogeneous looking. This form occurs of different sizes, some of them being twice the linear measurements of others, but, as mentioned, even the largest is exceedingly minute. Though thus *arthrodesmoid* in figure, apart from the *colour* and a general aspect of contents, the greatly differing sizes occurring in one and the same gathering, would prevent this being taken at all for any desmid; neither in this nor the following form is any gelatinous envelope apparent. A certain amount of a kind of movement shown by this form is, perhaps, not at all special, yet it is always somewhat strikingly evinced. I allude to a gentle jerking or oscillatory movement of each cell—a sort of quiet from side-to-side vibration, generally, *as if* on a pivot running through the isthmus, the radius of action being but restricted, yet constant. Owing to this gentle movement not being quite equable, in fact rather irregular, a change of position of the cells occurs, but no noteworthy or decided change of place. I would not be disposed to attribute any great importance to this, yet it is a minor phenomenon, which, in this little form, when met with, hardly ever fails to arrest one's attention. This must, I should think, be accounted a rare form, though it casually turns up in several places, especially from county Dublin and county Wicklow. I have not been able to see any new growth or formation of younger segments, nor any noteworthy difference in the examples now

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brief) visit of his to this country—an occasion of which I must ever retain a lively and pleasing recollection. We spoke, *inter alia*, of these forms, the subject arising from his having shown me a sketch of a minute form found by him in Sweden, which I at once recognised as most probably identical with that above recorded as *Tretrapedia Reinschiana.* I had fortunately, ere long, an opportunity to show Dr. Wittrock a fresh example not only of this, but likewise of the other form now here named *Tetrapedia setigera* (we were at the moment in the far West, in the middle of Connemara's wilds), and I hope that skilled and accomplished observer may not consider it too great a liberty on my part to mention that, whilst he identified the former as occurring in his country, he likewise concurred in my view, above expressed in regard to both, as to their nature and affinity.

* I regret that the figures in the plate (figs. 11 and 12) do not sufficiently accurately indicate the characteristic sought to be described by the words, "somewhat raised towards the angles;" the figures show the upper margin of the segment too uniformly concave, whereas each lateral portion or lobe of the segment presents rather a mamillate outline, that is the upper margin (as well as the lower) slightly convex towards the angles, but concave at the middle. It will be, of course, understood that the two figures (11 and 12) each show an individual, one with the "segments" lying horizontally, the other vertically, the deep sinus being that making the bilaterality, or *arthrodesmoid* contour.

and again offering themselves, save as before mentioned, in dimensions. *Bilaterality* is thus the speciality of this form.

Even still less offering any tangible grounds upon which to form a conjecture as to its mode of growth is the fourth form in question—one, however, seemingly undoubtedly of a similar nature, and hitherto apparently unobserved (figs. 14–17). This is also extremely minute, and is compressed, triangular, the sides each with a single deep rounded sinus, thus the cell three-lobed, the angles broadly rounded, and each tipped with an extremely slender linear bristle, in length almost equal to, or slightly longer than the diameter of the cell itself. The contents are extremely pale æruginous green. Thus the broad (or front) view might be comparable to the end view of certain Staurastra, or even, perhaps, still more aptly, it might be likened to a minute form of Polyedrium (Näg.), such as *P. trigonum*. But a second glance would suffice to place beyond the smallest doubt that we had no Staurastrum before us; and, apart from the minute size, the colour and aspect are abundantly characteristic to render it at once decisive that this can be no Polyedrium. No linear incisions have ever been seen to occur, consequently the cells do not present themselves as segmented, though forming three equally divergent lobes, separated by the deep rounded sinuses; hence no example has been met with showing any evidence of any mode of self-division. Their sizes vary, but not so much as do those of the preceding. The most singular feature is the possession of the very fine linear spine or bristle at each angle or extremity of the lobes, inasmuch as an appendage of such a nature would seem to be probably without a parallel in Chroococcaceous forms, unless, indeed, the tuft of hair-like filaments surrounding the terminal "heterocyst" of a Cylindrospermum may be something analogous. But there they are irregular, and more hair-like; here solitary, definite in position, longer, and more like a very delicate linear spine, that is, not thicker at the base, or at any portion of its length. I have met with this organism on several occasions in moor-pools, chiefly in the counties of Dublin and Wicklow; it is possible it may be pretty generally diffused, though not often seen, which may, indeed, in great part be due to its great minuteness. *Triradiate and setigerous* are thus the special features of this form.

Having thus tried to convey a conception of these four unicellular *figured* chroococcoids, the two first mentioned of which form Reinsch's genus Tetrapedia, as established by that author (*op. cit.*), it remains to consider in what manner the two latter, hitherto unrecorded, could be associated therewith. Taking the terms of the genus Tetrapedia, as founded, the two new forms would not correctly fall thereunder, the characters being based necessarily on the outward figure. If, indeed, it should be rigidly held that my two forms should be decidedly excluded from Reinsch's genus, in such case, fixing the generic limits on the same principle, each of these would seem to demand to be regarded as the types of two separate new genera—for to myself each would appear to be as distinct from each other as either from the two Reinschian forms.

But, nevertheless, all the four forms are, I venture to suppose, sufficiently clearly to be regarded as closely kindred—they are all compressed, angular, deeply subdivided either by narrow, even linear incisions, or by broad, angular, or rounded sinuses.

The third form referred to (figs. 11, 12), with its two broadly-cuneate segments is *comparable* to *T. Crux-Michaeli*, as it were, deprived of two opposite segments; no doubt, even for a moment supposing it possible to operate on an example so as actually to remove two of its segments, the result would still not be at all *identical* with my form in the contour of the remaining segments; therefore, so far as one can fairly judge, it would not be a reasonable assumption to regard it as a binate or, so to say, depauperated *variety* of *T. Crux-Michaeli* (Reinsch). It does seem the new form alluded to is not apparently at any time, so far as it has presented itself, divided "incisuris quaternis," yet still the approximation or "affinity" cannot but be regarded as sufficiently striking. The fourth form (figs. 14–16), with its three angles only, and its slender filiform or bristle-like processes, appears indeed more distinguished from the rest; but apart from having but three apices, its more projecting but comparatively less broadly rounded lobes, call to mind Reinsch's (unnamed) form, fig. 8, with its four semicircular lobes, cruciately arranged, and with a shallow subacute (instead of a broadly-rounded) sinus between them. As before, we might momentarily suppose it possible to deprive one of such forms as fig. 8, of *one* of its semicircular lobes, and the remainder "shoved round" so as to render the now (supposed) but three to become equidistant, still, even apart from the bristles, the forms would not be alike, yet, as in the previous case, the approximation or "affinity" cannot but be regarded as sufficiently striking; and further, my fourth form, this admitted, would seem thus (through such as fig. 8), to be connected even with *T. gothica* (Reinsch).

So far then as our acquaintance with these little algæ here referred to reaches, there appear to exist four (if not five), distinct, yet kindred forms of *figured* "Chroococcaceæ."—their remarkable shapes preclude their being regarded as "Lichen-gonidia," but whether mature plants or stages in the growth of any more complicated structures remains a problem. Ours are at least forms which here and there recur, and one can at once recognise them as always offering the same characteristics, and as maintaining their apparent individuality. Whether they are "species" or not, it may be a matter of convenience, should observers meet them elsewhere, and be able to throw a light upon them, to have at least a means of their recognition. For the reasons mentioned, it occurs to me as preferable (at least provisionally and temporarily) to record them under Reinsch's genus, if indeed that observer may not consider it unallowable so far to modify the terms thereof as to admit of its embracing the two new forms. It may be objected that the very name of the genus would preclude the admission of a *three*-lobed form into it, but the name Staurastrum is retained, though only a minority of the forms referrible thereto are cruciate or quadrangular in end-view; so also, with Triceratium—where four and five-angled forms occur,

and so on. I venture then to cast the descriptions of these forms as follows:—

Class, Phycochromaceæ.
Family, Chroococcaceæ.
Genus, Tetrapedia (Reinsch) mut. quodammodo char.

Cells compressed, quadrangular or triangular equilateral, becoming subdivided into quadrate or cuneate segments or rounded lobes, either by deep vertical or oblique incisions, or by wide angular or rounded sinuses.

Tetrapedia Gothica (Reinsch).

Cells quadrate, angles rounded, lateral margins emarginate at the middle, whereat afterwards deeply incised; each of the four roundly-angled quadrate segments thus produced becoming equal in dimensions to the original cell, and their lateral margins emarginate at the middle, whereat afterwards also deeply incised; each of the sixteen (secondary) roundly-angled quadrate segments thus produced becoming equal in dimensions to the original cell, and their lateral margins emarginate at the middle (whereat afterwards incised?); all the incisions perpendicular to the sides, rounded below, somewhat wide, of an equal average width throughout; ultimately a quadrate foramen through the cell at the central points of junction of the segments (the incisions afterwards completed and the segmented tablet breaking up?). In side view the single cell oblong, at the middle slightly concave at each side, ends rounded.

Plate XXI., Figs. 1 to 7. Diameter of single cell about $\frac{1}{4185}$ to $\frac{1}{3125}''$.

In a ditch, and in a mill-race (very scantily) near Erlangen.

(It seems to be probable that another distinct form exists, as above referred to, that figured by Reinsch* and reproduced in accompanying figure (fig. 8).—Should that form recur to him, probably he may be in a position to throw further light on it on a future occasion).

Tetrapedia Crux-Michaeli (Reinsch).

Cells quadrate, lateral margins entire, with two shallow concavities, each extending half the length of the sides, thus producing an obtuse-angled central prominence, deeply incised at the angles, incisions diagonal, rectilineal, deep, acute below, slightly expanding upwards, thus bisecting the angles and dividing the cell into four broadly cuneate segments, the upper angles of which are sub-acute (the incisions ultimately completed and the cell breaking up?); in side view lanceolate, ends acute.

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* *Op. cit.* t. II. fig. II. i.

Figs. 9, 10. Diameter of cell about $\frac{1}{3125}$ to $\frac{1}{2083}''$.

In running water (very scantily) near Erlangen: also (very scantily) near Mullingar, Ireland.

Tetrapedia Reinschiana, nov. sp.

Cells quadrangular, two opposite margins excavated by a wide triangular sinus, thus subdividing the cell into two broadly cuneate segments, connected by a wide isthmus, and somewhat convex on their lower margins; the other opposite margins of the cell, that is, the upper margins of the segments, very slightly concave at the middle, somewhat raised towards the sub-acute minutely apiculate outer angles;* in side view oblong, constricted at the middle, ends rounded.

Figs, 11, 12, 13. Diameter of largest cell met with (from angle to angle in both directions equal) from about $\frac{1}{2500}''$ to say one-third or even one-half smaller.

In moor pools, Counties Dublin, Wicklow, and Galway.

In venturing to associate Professor Reinsch's name with this species, I may take the opportunity to express the great pleasure with which I have availed myself of his interesting papers and correspondence, though unable to concur with certain of his views; and I would also use the occasion to thank him highly for the valuable and much esteemed favour conferred by his having been so good as to forward me copies of his memoirs.

Tetrapedia setigera, nov. sp.

Cells triangular, each lateral margin somewhat deeply excavated by a broad rounded sinus, dividing the cell into three lobes rounded at the ends, and each terminated by a very delicate straight bristle, in length about equal to the diameter of the cell; in side view oblong, somewhat inflated at the middle at each side, ends rounded, and each seen tipped by the bristle.

Figs. 14, 15, 16, 17. Diameter of cell (without bristles) about $\frac{1}{4000}$ to $\frac{1}{3400}''$ from end to end, including the bristles about $\frac{1}{1350}$ to $\frac{1}{1100}''$.

In moor pools, Counties Dublin, Wicklow, and Galway.

Of the genus Tetrapedia and the two original species therein included by him, Professor Reinsch has furnished in his work only the diagnosis (previously herein repeated), and the explanation of the figures, whence we can draw information or gain a knowledge of his views. His figures are given in the original upon a very large scale indeed, and hence probably calculated to induce misconception as to the actually very minute size of the forms; the majority of them are here reproduced upon a scale of some 400 diameters and the best "explanation of the figures"

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* See note, *ante*. p. 304.

that can accompany them will be simply a direct translation, though not taken in precisely the same order, from the original:—

Tetrapedia Gothica (Reinsch).

Fig. 1. A simple developed cell (Plate XXI.), whose lateral margins present the indication of division.

Fig. 2. A cell with the indication of division, the angles bluntly rounded.

Fig. 3. A cell [the division] somewhat more advanced.

Fig. 4. A four-celled family, the cells still connected in the middle by the angles, the depth of the incisions almost the breadth of the cells, the individual cells almost fully-formed—that is to say—already with the commencement of a division into a new cell-generation, the margins of the side-lobes of the cell somewhat emarginate at the middle.

Fig. 5. A four-celled family, the tablet (Scheibchen) furnished at the middle with a quadrangular *hole* (Loch).

Fig. 6. A sixteen-celled family, formed from four smaller families, still connected at the corresponding angles, all the cells of like figure, and presenting the indication of continuous division [No further reference is made on the part of the author to the holes].

Fig. 7. Side view of a cell.

Fig. 8. A four-celled family of peculiar form, which perhaps represents a distinct species, of which, however, I [Professor Reinsch] have observed but a single specimen; the cell cruciate, formed of four semicircular lobes; but whether the cells represent the developed condition, or the condition of beginning of a new division, I [Professor Reinsch] do not venture to decide; the dimensions as in a four-celled family of the ordinary form.

Tetrapedia Crux-Michaeli (Reinsch).

Fig. 9. An individual in the state as observed, showing the division furthest advanced.

Fig. 10. Side view of the same individual.

Tetrapedia Reinschiana (Arch.).

Figs. 11, 12. Front, or broad view.

Fig. 13. Side view.

Tetrapedia setigera (Arch.).

Figs. 14, 16. Front, or broad view.

Fig. 17. Side view.

Fig. 18. Portion of a filament of a minute Nostoc, with spores.

XXXV.—On a Minute Nostoc with Spores, with brief Notice of recently published Observations on Collema, &c. By William Archer. With Plate XXI. (Science).

[Read June 24, 1872.]

The appearance of a highly interesting and noteworthy communication from Professor Max Reess, conveying a description of certain novel experiments instituted by him on the growth of a Collema from the spores, and giving his views as to the bearing thereof as regards Nostoc,* which I have only just seen, recals to my recollection a seemingly remarkable, though isolated, example of a not uncommon minute aquatic Nostoc, with *spores*, brought forward by me at a recent meeting of our Microscopical Club, but not publicly exhibited, from want of time, and since then somehow overlooked to be recorded.

The little Nostoc, presenting the speciality to which I am desirous of directing attention, is a very minute one, though the dimensions of the subglobose or elliptic fronds vary much. It is rather common in moor and certain bog pools. On account of its small size, therefore readily capable of compression, and its pellucid character, the elegant arrangement of its tortuously twisted rather large moniliform filaments, is often nicely seen, and this causes it to be a very pretty and favourable illustrative example of its type, for examination in its entirety under the higher powers of the microscope. Its minute size calls to mind *Nostoc minimum* (Currey),† but in it the cells are described as quadrate, with a sinus at each side, lending a crenate outline to the filaments, and the heterocysts are large, whilst here the cells are orbicular, or for a time slightly flattened at the junctions, and the heterocysts are but slightly wider, though longer than the ordinary cells. This plant is probably identical with *Nostoc paludosum* (Kütz.), though, as regards anything to be deduced from the heterocysts, Kützing is silent. But the interesting point connected with it is a single example of it having presented indubitable "spores," of precisely similar nature to those in Sphærozyga, &c., but with the peculiarity of their being always placed singly between two heterocysts. The pairs of heterocysts with the intervening spore occurred at just about the same intervals as in ordinary examples occur the isolated heretocysts; the spores large, broadly elliptic, about one-third longer than broad; their diameter more than twice the diameter of the heterocysts, about thrice the diameter of the ordinary cells; the "bright points" of the heterocysts not very conspicuous. (See Pl. XXI., fig. 18).

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* Professor Max Reess: "Ueber die Enstehung der Flechte *Collema glaucescens* Hoffm., durch Aussaat der Sporen derselben auf *Nostoc lichenoides*, Vauch." In "Monatsb. der k. Akad. der Wiss. zu Berlin," Oct., 1871, p. 523.

† Currey "On Freshwater Algæ," in "Quart. Journ. of Micr. Sci.," vol. vi. (1st ser.), page 216.

I would explicitly deprecate any supposition that the observation was founded on any mere isolated filament, met with in the same material as the rest of the ordinary examples of this Nostoc around, and assumed by me to have emanated from some of them, and, therefore, possibly that of some other genus. The filaments were not isolated, but, contorted about in quite the ordinary way, were still involved in the parent matrix, which was bounded by the distinct pellicle, or "periderm," generically characteristic, and in all respects, save the remarkable speciality described, this example was absolutely the same as the others in the same gathering; in fact, the little Nostoc was intact. It might be said, possibly, this little plant was rather a Monormia, but the definite periderm to the rounded fronds places a bar to the assumption, and I do not think any observer would see it and pronounce it other than a Nostoc.

In making a drawing for illustration, it is of course unnecessary to present more than one spore, with its adjacent heterocysts and a few cells of the filament. To give the total frond, and its long, tortuously looped and curved filaments, with their numerous spores and heterocysts, and to convey an idea of the matrix, with the bounding periderm, would have been an unnecessary labour and expense, and to carry it out on the scale of some 400 diameters would have occupied a very considerable space.

I would now advert to Professor Reess's views, as given in his memoir above alluded to. This observer is an adherent of the hypothesis already propounded by Professor Schwendener, as regards the nature of Lichens, who, in his turn, seems possibly to have had suggested to him the working out of some such idea as he has arrived at, by the alternative conclusion put forward by Professor de Bary, as one or other being a necessary outcome or result deducible from the existent knowledge of the gelatinous Lichens (Gallertflechten) or the Collemaceæ and allies, and seemingly embracing also Ephebe in his generalisation. This the latter thus enunciates—"Either the Lichens in question are perfectly developed states of plants whose imperfectly developed forms have hitherto stood amongst the Algæ as the Nostocaceæ and Chroococcaceæ. Or the Nostocaceæ and Chroococcaceæ are typical Algæ—they assume the form of Collema, Ephebe, and so forth, through certain parasitic Ascomycetes penetrating into them, spreading their mycelium into the continuously-growing thallus, and frequently attached to their phycochrome-containing cells."* The former of these hypotheses, as is well known, has many supporters, and, seemingly, a considerable amount—at least, in certain instances—of evidence in its favour. The latter hypothesis, on the other hand, has found, if fewer, even more staunch adherents, most prominent amongst whom are Schwendener and Reess.

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* Professor A. de Bary: "Morphologie u. Phys d. Pilze, Flechten und Myxomyceten"—in Hofmeister's "Handbuch der phys. Bot.," Bd. ii., p. 291.

Relinquishing the opinions supported by him in the earlier portions of his elaborate memoir on the Lichen-thallus,* Schwendener, before he concludes, propounds the doctrine that not only are the "Lichens" in question (the Collemaceæ, alluded to by de Bary) no "Lichens," but that the whole class, without exception, falls under the same category; that is to say, that each is to be regarded as some one or other Algal-type which has become, as it were, the home or residence of a parasitic growth—the combination of the two being, in point of fact, the so-called Lichen. His views on the question the author has given more at large, in relation to various types, in a subsequent memoir.† These he states generally thus:—"As the result of my researches all these growths [Lichens] are not simple plants, not individuals in the ordinary sense of the word; they are rather colonies, which consist of hundreds and thousands of individuals, of which, however, one alone plays the master, whilst the rest, in perpetual captivity, prepare the nutriment for themselves and their master. This master is a fungus of the class of Ascomycetes, a parasite which is accustomed to live upon others' work; its slaves are green algæ, which it has sought out, or indeed caught hold of, and compelled into its service. It surrounds them, as a spider its prey, with a fibrous net of narrow meshes, which is gradually converted into an impenetrable covering; but, whilst the spider sucks its prey and leaves it lying dead, the fungus incites the algæ found in its net to more rapid activity—nay, to more vigorous increase. . . . If this mode of illustration be permissible, this fungus forms a remarkable contrast not only to the predatory and murderous spider, but, in quite an analogous way, to the vine and potato-fungus, as well as all other fungi which vegetate in living organisms, and destroy their host-plant, or host-animal, in the unequal struggle."‡ Such, "popularly" expressed, is Schwendener's view as to "Lichens" at large, which he now holds and supports. This quotation, I would venture to suggest, would seem sufficiently to convey its own refutation of the hypothesis, inasmuch as this assumed *parasitic fungus* does *not destroy* or live upon its assumed *algal-host*. If the "parasite" cannot be a "fungus" it must be something else—that *something else* no more nor less than the veritable "lichen," though it may be, indeed, but in part represented; though, of course, on all hands it is agreed that Lichens and Fungi, save the gonidia, have between them no absolute line of demarcation.

Seemingly, at first, more impressed with the applicability of Schwendener's hypothesis to the Collemaceæ, though he no doubt afterwards accepts its complete tenability as regards the whole class of the "Lichens," Reess conceived the idea of "sowing" the spores of Collema

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* Dr. S. Schwendener—"Untersuchungen ueber den Flechten-thallus," in Prof. Nägeli's "Beiträge zur wissensch. Botanik," Hft. 4, p. 195 (1868).

† Dr. S. Schwendener—"Die Algentypen der Flechtengonidien," Basel, 1869.

‡ Schwendener—"Die Algentypen," etc., p. 3.

upon the substance of Nostoc, and a description of the experiment and its results forms the subject of his memoir previously alluded to.* He states, indeed, that the spores of Collema can be readily enough made to germinate upon any moist substratum, such as a glass-plate, stones, and so on, and will slowly produce even a branched and sparingly jointed growth, but this goes on only so long as the reserve-stuff is supplied by the spore, but when this is exhausted the hypha-mass thus produced, though it may survive even weeks, will then slowly die off. But when he brings a spore or the young hypha upon the Nostoc, it at once becomes further developed, sending more or less copiously through its surface many branches, and penetrating within. Soon, however, they cease to increase in length, become swollen at the points and at other places, and become attached by these swellings upon the Nostoc. Thereupon thinner processes become sent further into the gelatinous mass of the Nostoc, from the swellings; these become branched, and, tortuously surrounding the chains of gonidia, form, in fact, the "Collema-mycelium," and the complete transformation or conversion of the "Nostoc" into the Collema is brought about by the hypha producing a peripheral stratum of fibres, from which break forth, through the "Nostoc-jelly," the first root-hairs. Such an *artificially* produced "Collema" the author had not been able to rear up as far as the production of fructification (apothecia), but he doubts not the tenability of the assumption that every Collema in free nature is a "*Nostoc,*" thus made the nidus for the development of the spores, evolved of course from a preceding "Nostoc" so naturally inoculated (as one might say), that is to say, in other words, a preceding compound organization which is known as "Collema." Such is, as briefly as possible, the result of Reess's experiences, and the views he holds; it would lead too far to endeavour to go more closely into the arguments and statements of Reess and Schwendener—those of the latter applied to the Lichens at large, not the Collemaceæ only—but it may not be wholly without use to have directed attention to their remarkable memoirs.

Basing his opinion, as it would seem, at least mainly, upon the result of the experiments of Professor Reess alluded to, Professor Cohn† would exclude the Collemaceæ from the Lichens, which (without these), as a Class, he would retain, remarking that "he knows no Algæ which could be transformed by the influence of a fungus into Usnea, Cladonia, Cetraria, etc., but that it appears to him that the parasitism has been rendered by de Bary and Reess extremely probable for the 'Collemaceæ.'"

Schwendener himself, in his later memoir,‡ figures certain Nostoc

* Prof. Reess—"Ueber die Entstehung der Flechte *Collema glaucescens*, Hoffm. durch Aussaat der Sporen derselben auf *Nostoc lichenoides*, Vauch." in "Monatsb. der k. Akad. der Wissensch. zu Berlin," Oct. 1871, p. 523.

† Prof. Dr. F. Cohn—"Conspectus Familiarum crytogamarum secundum methodum naturalem dispositarum," in "Hedwigia," No. 2, 1872, p. 17.

‡ "Die Algentypen," etc., pp. 28, 99, t, II., ff. 13-15.

specimens whose gelatinous matrix is seen to be penetrated by what he denominates fungal threads (Pilsfaser), and these he points to as evidence of the truth of his view; that is, that they become the hypha, and that the phenomena of growth thereby induced absolutely *convert* the "Nostoc" into "Collema;" and he firmly holds his figures *prove* the case. Now, Reess, referring to these very figures, conceives the fungal threads depicted must be strictly those of a (destructive) fungus —a mould, in point of fact; he thinks, indeed, they may be anything whatever, but one thing clearly he avers, be they what they may, they are by no means a Collema-hypha, founding his opinion, of course, upon the knowledge gained from his recently conducted experiments. So that whatever may be the opinion of other observers as to the result of the researches of Reess, at least the examples adduced by Schwendener relating to Collema, it would appear, must be held as inconclusive.

It may, perhaps, be not inopportune to observe that, as must be well known, the gelatinous masses of those Algæ which grow on wet rocks and such situations, be they Palmellaceous or Chroococcaceous, are prone to be more or less permeated by "myceloid" threads, and even some such as would fairly well accord with those Reess depicts for Collema, though not so copiously branched, may not be unusual. Some of these threads are, at least occasionally, those of indubitable (devastating) fungi, which, when they "attack" certain cells, destroy them; other threads, doubtless quite distinct, can apparently live independently and innocuously, though probably drawing nutriment from the common mucous matrix. What a *monstrous* and *abnormal* "Lichen-thallus" thus not unfrequently comes to view—a variable "hypha" interruptedly running hither and thither, and accompanied by "gonidia" of very heterogeneous character! The plant named by Kützing, *Trichodictyon rupestre*, which can hardly be doubted to be the same as *Cylindrocystis crassa*, de Bary, is frequently (though not always) accompanied by a number of fine filaments (which seem, however, to be inarticulate), twisted in and out through the gelatinous mass made by the alga, but so running as to leave rounded spaces between, containing the groups of the Cylindrocystis-cells; they seem, in fact, to urge their way between the more dense mucous envelopes formed round the groups of dividing cells, simply because they find the intervals, being softer, more readily permeable. These filaments, whatever their nature really may be, cannot be doubted, I should think, to be foreign, though they were introduced into the generic characters by Kützing, being considered by him as somehow a portion of the structure of the alga, which, indeed, itself reproduces by conjugation, and is, no doubt, in fact, a desmid.

Schwendener claims as the foundation or basis for the production of "Collemaceæ" only such nostochaceous plants as live in moist or wet habitats—the entirely aquatic forms (Trichormus, Sphærozyga, Cylindrospermum, Dolichospermum), he considers, being inaccessible under water, are protected from the attack of the parasite, and thus "cannot

enter into the 'gonidia question.'" The fact that these latter form independent "spore-cells" (reproducing the plant), he would seem, so far as we can judge, to hold as having no material, if any, bearing on the question, for he dwells only on their being submerged as giving them an immunity. "But in any case," he says, afterwards, further on, as regards the question, "whether certain species of Cylindrospermum pass into the 'gonidia state' [that is, become the basis of Collemaceæ] remains for so long doubtful, till the transition, here alone decisive, be observed. In the Collema-thallus itself a decision is of course no longer possible, since the spores characteristic of Cylindrospermum apparently just as little come to development in the gonidial state, as do the 'manubria' of the Rivularieæ." (This last allusion has a bearing on Lichina, &c., which the author thinks have plants appertaining to Rivularieæ for their basis, but without *manubria.*) I would venture to suggest, were such Algæ as these truly seized upon by this completely innocuous parasite—nay, which, if the hypothesis be true, rather tends to favour the growth and vigour of the "gonidia" —we should hardly expect that, on the other hand, the innate or inherited tendency to produce "spores" would at the same time become wholly extinguished. It would, I should venture to suppose, seem probable, even admitting the views of Schwendener and Reess as regards Nostoc, that Cylindrospermum is not likely to have anything to say to the "gonidia question." But the isolated observation, for the first time herein recorded, would seem to show that Nostoc, too, may form spores, though it be, indeed, so very exceptionally, and so extremely rarely.

The main object, then, of the present communication is to offer the following three suggestions which occur to me:—

1. To suggest the possibility that, if we may conceive Dolichospermum, &c., excluded from the "gonidia question" as forming special fruit (that is, "spores"), so might we regard Nostoc as excluded, though its formation of spores be so extremely rare. Seemingly, indeed, the capacity of forming spores by an algal species, supposed to become occasionally *lichenized,* is not a reason *against* the hypothesis as viewed by Schwendener—he only assumes that such an example of the alga surrenders, or leaves in abeyance, its tendency to the production of spores.

2. To suggest that there are veritable lichens which live submerged, and produce their apothecia. I presume, however, it might be replied that such may have received their inoculation by the parasite during some season of drought, when the *alga* lay "high and dry."

3. To suggest the possibility that the spores of Collema, if "sown" on some other gelatinous substratum, besides that of Nostoc—say, for instance, a Palmella or Mesotænium—might equally well germinate, penetrate therein, and develop a hypha.

There seems, I venture to think, no *à priori* reason against this latter supposition—inside the Nostoc, the "reserve-stuff" of the spore being exhausted, and the chains of Nostoc filaments admittedly intact,

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and no "root-hairs" as yet formed, the only next *immediate* source of nutriment for the growing hypha would, I imagine, in the experiment of Reess, appear to have been the "Nostoc-jelly." Now a "Palmella-jelly," or a "Mesotænium-jelly" (both aërial, that is, not under water), would seem in themselves to be possibly just as likely to afford the requisite *pabulum* for the germinating and growing Collema-spore. If this conjecture should be borne out, which I would indeed put with all diffidence, what would be the result of Reess's experiments, or rather, what proven thereby? Such a combination (*if* capable) with a Palmella or a Mesotænium would not be "Collema," because it would not have "nostochaceous" gonidia, nor the characteristic periderm. If, indeed, we might for a moment assume that which direct experiment alone could prove, and a germination of spores and penetration of the hypha of a Collema with a Mesotænium effected, such a "lichen-thallus" would be, I apprehend, unprecedented—a hypha *like* other lichen-hyphæ, no doubt (but *known* to be that of a Collema), with large elliptical or cylindrical "gonidia" containing a central "chlorophyll-plate," and which would probably (in free nature at least, even though accompanied by the hypha,) go on and produce *zygospores!*

I trust that the reader of the foregoing remarks will understand that I put them forward but with a great amount of diffidence; it was the occurrence of my little spore-bearing Nostoc, which suggested to me to venture to do so. Isolated, indeed, as was that example, still no matter from what aspect viewed, even though it be urged that we should look upon it as "abnormal" on account of its rarity, it cannot, I apprehend, but be regarded under any circumstances as to a certain extent suggestive and as possessing at least some amount of significance.

XXXVI.—On a New Approximation to the Orbit of the Binary Star ξ Ursae Majoris. By Robert Stawell Ball, LL.D., M.R.I.A. With Plates XXII. & XXIII. (Science).

[Read June 24, 1872.]

The orbit of this star has been computed by Savary, "Connoiss des Temps." 1830, by Herschel II., "Trans. Astronomical Society," Lond. Vol. V., p. 209, by Mädler, "Dorpat Observations," Vol. IX., by Villarceau, "Astron. Nachrichten, Vol. XXIX.," and by others. It might appear that any further investigation of a subject which had engaged the attention of so many eminent astronomers was superfluous. It will, therefore, be necessary to recount the circumstances which render a new determination of the orbit desirable.

ξ Ursae Majoris is a binary star, whose components are of the 4 and 5 5 magnitudes respectively—(Smyth). The periodic time of this star is, probably, a little less than sixty years. The first recorded observation is by Herschel I., in the year 1781. The star has, therefore, been watched during the entire of one revolution, and half of another. All the computations of the orbit indicate that the star passed through periastron

between the spring of the year 1816 and the spring of 1817. Before the star reached its last periastron, we have only three observations available; namely, that already mentioned (1781), and two others by the same eminent observer in 1802 and in 1804. These last observations, as Herschel II. remarks, having only an interval of two years, are of little more value than a single observation. After 1804 there appears to have been a much to be regretted lacuna in the observations, the next recorded being one by Struve in 1819.* It is, therefore, manifest that, during the twelve or thirteen years preceding the last periastron passage of the star, and for two years subsequent to the passage, no observation has been recorded. Now, in this interval, one star swept round the other with amazing velocity, accomplishing a change of position of no less than 168° in the fifteen years. Had a few observations, distributed over this critical period, been available, the additional information would have enabled these astronomers who have investigated the subject to have determined the elements of the orbit with the utmost attainable precision. So far as the value of observations are concerned, the most critical epoch is, perhaps, not that of the periastron passage, but the epoch at which the angular velocity of the position angle is a maximum. In the present case, this occurs three years previously to periastron; thus, about 1814, the position angle changed at a rate exceeding 20° per annum, while at periastron the rate was about 13° per annum; this shows still more clearly how desirable it would be to have had some observations between 1804 and 1819.

Now, however, the star is rapidly approaching its second periastron, through which it will pass early in 1876; consequently, the numerous observations of the last few years have, to a great extent, supplied the want of observations already referred to. It is believed, that by the aid of these observations, a new series of approximate elements have been found, which represent the entire system of observations with tolerable fidelity.

The angle of position of the star is now (1872), changing with extreme rapidity, and a careful series of observations for the next ten years will be of the greatest interest in sidereal dynamics.

The elements of the four orbits already referred to, are given in Table I.†

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* The observations here referred to are taken from "Dawes' Catalogue of Micrometric Measures," M.R.A.S., vol. xxxv., p. 353.

† Herschel, "Outlines of Astronomy," 4th Ed., p. 573.

TABLE I.

Elements of the Orbit of the Binary Star ξ Ursae Majoris.

Semi axis Major.	Eccentricity.	Position of Node.	Inclination.	Angle between Major Axis and Line of Nodes.	Period in Years.	Perihelion Passage, A. D.	Authority.
a	e	Ω	γ	λ	P	ϵ	
3″.857	0·41640	95°·37	59°·67	131°·63	58·262	1817·25	**Savary.**
3 ·278	0·37770	97 ·78	56 ·10	134 ·37	60·720	1816·73	**Herschel II.**
2 ·417	0·41350	98 ·87	54 ·93	130 ·80	61·464	1816·44	**Mädler.**
2 ·439	0·43148	95 ·83	52 ·82	128 ·95	61·576	1816·86	**Villarceau.**

For a definition of the meaning of the elements, reference may be made to Sir John Herschel's beautiful memoir already referred to (p. 172).

We next proceed to compare these orbits with the observations. Amid the multitude of observations available for this purpose, twenty-two have been selected, distributed fairly over the ninety years during which the star has been observed; and, wherever a choice has been possible, the results which have the greatest weight have been adopted. The selection has principally been made from "Dawes' Catalogue of Micrometrical Measurements" already referred to; other observations have been supplied by the kindness of Dr. Brünnow.

The comparison has only been instituted between the observed and computed angles of position, as the angle of position is susceptible of much more precise measurement than the distance. The result of the comparison is shown in Table II. The first column contains the number of the observation; the second, the observer on whose authority the angle of position is given; the third contains the epoch, expressed in years A. D., and decimals of a year; the fourth contains the observed position; the fifth contains the positions computed from Savary's elements; the sixth contains the difference between the positions computed from Savary's elements and the observed positions.

The remaining columns contain the computed positions and differences for the elements determined by the three other astronomers referred to.

TABLE II.

Comparison of the Elements given in Table I., with Observation.

				Savary (1830).		Herschel II. (1832).		Madler.		Villarceau.	
No.	Observer.	Epoch.	Observed position.	Calculated position.	Difference.	Calculated position.	Difference.	Calculated position.	Difference.	Calculated position.	Difference.
1	Herschel I., ...	1781·97	143°·78	143°·89	+ 0°·11	140°·08	− 3°·70	14 85	− 0°·93	144°·12	+ 0°·34
2	Herschel I., ...	1802·09	97 ·52	97 ·40	− 0 ·12	93 ·92	− 3 ·60	97 ·72	+ 0 ·20	97 ·73	+ 0 ·21
3	Herschel I.. . . .	1804·08	92 ·63	93 ·07	− 0 ·34	88 ·52	− 4 ·11	92 ·45	− 0 ·18	92 ·55	− 0 ·08
4	Struve, ...	1819·10	284 ·55	284 ·97	+ 0 ·42	285 ·13	+ 0 ·58	284 ·54	− 0 ·01	285 ·60	+ 1 ·05
5	Herschel II. and South,	1823·29	258 ·45	257 ·45	− 1 ·00	258 ·37	− 0 ·08	256 ·60	− 1 ·85	254 ·78	− 3 ·67
6	South, ...	1825·22	244 ·53	245 ·50	− 0 ·97	246 ·45	+ 1 ·92	244 ·47	− 0 ·06	242 ·38	− 2 ·15
7	Struve, ...	1827·27	228 ·27	231 ·50	+ 3 ·23	232 ·68	+ 4 ·41	230 ·97	+ 2 ·70	229 ·03	− 0 ·76
8	Dawes, ...	1832·27	196 ·72	191 ·69	− 5 ·03	195 ·40	− 1 ·32	196 ·39	− 0 ·33	196 ·43	− 0 ·29
9	Dawes, ...	1840·29	150 ·85	143 ·65	− 7 ·20	148 ·92	− 1 ·93	153 ·80	+ 2 ·95	155 ·48	+ 4 ·63
10	Dawes, ...	1842·27	144 ·76	136 ·50	− 8 ·26	141 ·48	− 2 ·28	146 ·60	+ 1 ·84	148 ·33	+ 3 ·57
11	Dawes, ...	1843·28	142 ·17	133 ·29	− 8 ·88	138 ·15	− 4 ·02	143 ·35	+ 1 ·18	144 ·98	+ 2 ·81
12	Dawes, ...	1849·30	126 ·58	118 ·44	− 8 ·14	122 ·27	− 4 ·31	127 ·47	+ 0 ·89	128 ·58	+ 2 ·00
13	Miller, ...	1852·13	122 ·28	112 ·84	− 9 ·44!	116 ·22	− 6 ·06	121 ·37	− 0 ·91	122 ·22	− 0 ·06
14	Jacob, ...	1853·20	119 ·47	110 ·85	− 8 ·62	114 ·03	− 5 ·44	119 ·17	− 0 ·30	119 ·93	+ 0 ·46
15	Dawes, ...	1854·36	115 ·87	108 ·72	− 7 ·15	111 ·73	− 4 ·14	116 ·85	+ 0 ·98	117 ·55	+ 1 ·68
16	Dembowski, ...	1858·20	108 ·09	101 ·67	− 6 ·42	104 ·12	− 3 ·97	109 ·29	+ 1 ·20	109 ·70	+ 1 ·61
17	Dembowski, ...	1863·23	96 ·66	90 ·92	− 5 ·74	92 ·85	− 3 ·81	98 ·54	+ 1 ·88	98 ·48	+ 1 ·82
18	Engelmann, ...	1865·12	91 ·42	85 ·59	− 5 ·83	87 ·55	− 3 ·87	93 ·67	+ 2 ·25	94 ·00	+ 2 ·58
19	Dembowski, ...	1866·30	86 ·76	81 ·50	− 5 ·26	83 ·65	− 3 ·11	90 ·20	+ 3 ·46	90 ·68	+ 3 ·92
20	Dembowski, ...	1867·31	82 ·22	77 ·24	− 4 ·98	79 ·78	− 2 ·44	86 ·82	+ 4 ·60	87 ·52	+ 5 ·30
21	Dembowski.	1868·30	77 ·50	72 ·02	− 5 ·48	75 ·27	− 2 ·23	83 ·02	+ 5 ·52	84 ·02	+ 6 ·52
22	Brünnow, ...	1872·28	24 ·19	20 ·57	− 3 ·62	41 ·62	+ 17 ·43!	57 ·19·	+ 33 ·00!	62 ·10	+ 37 ·91!

It will be observed, that Savary's elements represent the observations up to No. 6 very well. After No. 6, the calculated position falls behind the observed position, the difference reaching a maximum in No. 13, where it amounts to 9°.44; the discrepancy then decreases until in No. 22 the difference only amounts to 3°·62. Savary's elements, though the earliest in point of date, do not exhibit such large discrepancies as either of the three remaining orbits. No observations were available for the determination of Savary's orbit later than No. 7.

The elements given by Herschel II. give for No. 22 a calculated position 17°.43 in excess of the observed position; with this exception, the greatest difference is 6°·06 in No. 13. With reference to this determination, Herschel II. remarks, "the case is one highly unfavourable for the application of my method; and, moreover, the resulting elements are those of a first approximation only." In the computation of these elements, as in those of Savary, no observations later than No. 7 were available.

Mädler's elements represent the first eighteen observations with surprising fidelity, and there is no very serious discrepancy until the last observation, No. 22, when the calculated position exceeds the observed position by 33°.

Villarceau's elements are much of the same character as Mädler's, and the differences (though greater than Mädler's) are not very serious until No. 22, where the calculated position is 37°·91 greater than the observed position.

If, as there cannot be a reason for doubting, one star of the pair has a relative motion about the other, in an ellipse of which the fixed star is the focus, it can hardly be maintained that any one of the four sets of elements which have been examined represent that ellipse with sufficient accuracy.

In the absence of Mr. Brünnow's observation of 1872·28 (No. 22), Mädler's elements would, no doubt, have fair claims; but that observation (in addition to those which immediately precede it) necessitates some change in the elements.

The extremely elegant method invented by Sir John Herschel, and described by him in his memoir already referred to, appears a most appropriate method for deducing, at all events, approximate elements. It is proposed by the author of the present paper, to apply this method to a new determination, embracing, for the purpose, observations between 1781·97 and 1872·28. The application of the method to the present instance will be described in detail.

A sheet of paper neatly divided into square millimetres, by ruled lines, with every tenth line darker than the rest, is mounted upon a drawing-board.

On a horizontal line abscissæ are marked at the rate of two millimeters per annum, corresponding to every date in Dawes' list of positions of ξ Ursae, already referred to. To these are added a few positions quoted by Herschel, not included in Dawes' list, and from No. 18 to

No. 22 of Table II. In all, sixty-four mean results of observation are employed.

Ordinates are then erected on the scale of one millimeter to each of the angles of position.

All the points thus constructed would, if the observations were perfect, lie upon a curve. The next task is, therefore, to draw among all the points the curve which, on the whole, coincides most nearly with the observations. The abundance of points in the lower portion of this curve renders its form in that neighbourhood a matter of but little uncertainty ; this will enable the form of the curve in the earlier portions to be corrected, where there are but few points to guide the hand in its formation. It should be remembered, in setting up the ordinates, that the positions of 1781·97, 1802·09, 1804·08 are each to be increased by 360°, as otherwise the curve would be discontinuous.

The curve, having been completed, is now submitted with this communication to the Academy. (Plate XXII., Science).

Ordinates are read off upon this curve, for every five years. The angles of position, thus interpolated, are given in the third column of Table III.

TABLE III.

The Angles of Position and the Distances in the Projected Ellipse, deduced from the Corresponding Epochs by the Interpolating Curve.

No.	Epoch. t	Interpolated Angle of Position. θ	Distance.
1	1785	136° ·0	84·5
2	1790	123 ·0	95·1
3	1795	112 ·5	97·1
4	1800	101 ·5	92·6
5	1805	88 ·5	77·8
6	1810	59 ·0	40·4
7	1815	328 ·0	39·1
8	1820	280 ·0	51·2
9	1825	245 ·5	54·1
10	1830	212 ·0	52·0
11	1835	181 ·0	56·4
12	1840	158 ·5	65·1
13	1845	137 ·5	82·5
14	1850	126 ·0	98·2
15	1855	115 ·5	91·8
16	1860	104 ·5	93·1
17	1865	91 ·3	79·5
18	1870	64 ·0	50·1
19	1872·28	24 ·2	28·8

In No. 19 the angle of position is inferred directly from observation. The other eighteen positions are derived from the curve.

Tangents are next drawn to the curve at the points corresponding to the dates of Table III. From the intersection of these tangents with the squares upon the ruled paper, the values of $\frac{dt}{d\theta}$ are readily ascertained. The last column of the Table contains the values of

$$\sqrt{20{,}000 \frac{dt}{d\theta}}$$

t being expressed in years, and θ in degrees.

The quantity $\sqrt{\frac{dt}{d\theta}}$ is proportional to the distance between the two stars; this follows from the law of the description of equal areas in equal times, a property which, if true in the original ellipse, is also true in the projected ellipse.

According to the process adopted in this method, the real distances are discarded (for the present at least), and the projected ellipse is to be constructed from the interpolated angles of position and computed distances, that is, from the third and fourth columns of Table III.

From a line Sn, Fig. 2, where S is the larger star supposed fixed, the points 1, 2, &c., 19, are set off, For example, the angle 7 Sn, is 328°, and the distance S 7 is 39·1 millimeters, being the angle and distance taken from No. 7 of Table III.

If the observations were perfect, and the graphical construction correct, we should find, assuming that the law of gravitation holds in the binary star, that the points 1 to 19 are all on the circumference of an ellipse. S would not be situated in the focus, unless in the exceptional case where the plane of the ellipse was normal to the visual ray.

It is manifest that no ellipse could pass directly through all the points, and it is, therefore, our duty to construct the ellipse which, upon the whole, passes most nearly through and among the system. The ellipse found by trial is shown in Plate XXIII. (Science). This ellipse passes through 1, 3, 11, 13, extremely close to 2, 9, 10, 16, 17, 18, tolerably close to 4, 5, 6, 8, while it is at some distance from 7, 12, 14, 15, 19.

The remainder of this portion of the investigation will proceed upon the assumption that, if the observations were perfect, the projected ellipse would not be different from the ellipse thus found.

Through M draw a tangent to the ellipse, and a diameter through C parallel to the tangent, then CA ($= a'$) and CD ($= b'$), are the projections of the major axis (a), and minor axis (b) of the real ellipse.

We have now to deduce the real ellipse from the projected ellipse. By measurement we find—

$$\begin{aligned} CA &= 62{\cdot}6 = a' \\ CD &= 57{\cdot}7 = b' \\ CS &= 23{\cdot}7 \\ nSA &= 312^\circ = \alpha \\ nSx &= 70^\circ = \beta. \end{aligned}$$

S is the focus of the real ellipse, C the projection of the centre of the real ellipse; AM is therefore the projection of the major axis of the real ellipse, whose eccentricity must be

$$\frac{CS}{CA} = 0{\cdot}3786.$$

The ratio $$\frac{a}{b} = \frac{1}{\sqrt{1 - e^2}} = 1{\cdot}080,$$

and $$\frac{a'}{b'} = \qquad = 1{\cdot}085.$$

If Ω be the angle between the intersection of the real and the projected ellipses and the line Sn, and if γ be the inclination of the planes of the two ellipses,

then
$$\tan 2\,\Omega = \frac{\left(\frac{a'}{b'}\right)^2 \sin 2\alpha + \left(\frac{a}{b}\right)^2 \sin 2\beta.}{\left(\frac{a'}{b'}\right)^2 \cos 2\alpha + \left(\frac{a}{b}\right)^2 \cos 2\beta.}$$

$$\cos\gamma = \sqrt{-\tan(\Omega - \alpha).\tan(\Omega - \beta).}$$

Whence we deduce

$$\begin{aligned} \Omega &= 101^\circ{\cdot}28 \\ \gamma &= 53^\circ{\cdot}07, \end{aligned}$$

λ is the angle between the line drawn from S through perihelion in the real ellipse and the line of nodes. We have

$$\tan\lambda = \sqrt{-\frac{\tan(\alpha - \Omega)}{\tan(\beta - \Omega).}}$$

whence, $$\lambda = 135^\circ{\cdot}32.$$

We have now to deduce the periodic time, and also the epoch, when the star last passed through periastron. We have the formulæ—

$$n(t - \epsilon) = u - e \sin u.$$

$$\tan \frac{v}{2} = \sqrt{\frac{1+e}{1-e}} \tan \frac{u}{2},$$

$$\tan (v - \lambda) \cos \gamma = \tan (\theta - \Omega).$$

A value of θ being substituted in the last of these equations, v becomes known, whence u is known by the second equation; and by substitution in the first, we have a relation between n and ϵ, when the known value of t is introduced.

At the date 1802, the value of θ, read off from the interpolating curve, is 96·5, and at 1872·2, the value of θ is 24°·19.

From these we deduce

$$n = -6^\circ{\cdot}012,$$

$$\epsilon = 1816{\cdot}405,$$

whence the periodic time is,

59·88 years.

It remains to determine the semi-axis major of the true ellipse. In the determination of this element alone do we employ the observed distances.

Observed measures of the distances from Nos. 4 to 22 are given in Table IV.

TABLE IV.

The observed Distances of ξ Ursae Majoris, compared with the Radii vectores in the Projected Ellipse, Fig. 2.

No.	Observed Distance.	Distance on Fig. 2, in Millimetres.
4	2″·560	51·0
5	2 ·810	55·5
6	2 ·442	58·5
7	1 ·715	52·4
8	1 ·761	53·5
9	2 ·445	72·0
10	2 ·441	77·5
11	2 ·481	80·0
12	3 ·018	93·5
13	2 ·898	97·0
14	3 ·010	97·4
15	2 ·957	97·3
16	3 ·182	94·5
17	2 ·557	79·0
18	2 ·442	71·0
19	2 ·060	65·0
20	1 ·900	59·5
21	1 ·740	54·0
22	1 ·315	32·5
Total, .	45″·729	1336·1

The observed distances are given in the second column; the corresponding distances in millimeters from S to the circumference of the ellipse, Fig. 2, are found in the third column. We have now to find the angular magnitude corresponding to one millimeter, on the scale we have adopted. The sum of the observed distances is 45″·799, the sum of the corresponding quantities in the third column is—

$$1336{\cdot}1.$$

Dividing the former by the latter, we have as the average value of one millimeter

$$0''{\cdot}0342247,$$

whence, $$AC = 62^{\text{mm}}{\cdot}6 = 2''{\cdot}1425.$$

It is easily seen that

$$a = AC \frac{\cos (nSA - \Omega)}{\cos \lambda},$$

$$= 2''1 \cdot 425 \frac{\cos 30^{\circ} \cdot 43'}{\cos 44^{\circ}. 41'}$$

$$= 2'' \cdot 591.$$

We have yet to make a small change in the value of Ω. We can calculate the quantity $\theta - \Omega$, when we know the time and the other elements. The difference between $\theta - \Omega$ thus computed, and the observed value of θ gives a value of Ω. This quantity has been thus deduced from the observations, and the mean value is

$$103^{\circ} \cdot 6'$$

Collecting the results, we have

TABLE V.

New Approximate Elements of the Binary Star ξ Ursae Majoris.

Semi-axis Major.	Eccentricity.	Position of Node.	Inclination.	Angle between Major axis and line of Nodes.	Period in Years.	Mean Motion.	Perihelion Passage, A.D
a	e	Ω	γ	λ	P	n	ϵ
$2'' \cdot 591$	0·8786	$103^{\circ} \cdot 6$	$53^{\circ} \cdot 1$	$185^{\circ} \cdot 8$	59 88	$6^{\circ} \cdot 012$	1816.405

In Table VI. will be found the comparison of the angles of position, computed by the new elements, with those given by the observations.

The observations which have been employed are the same as those of Table II., with two more (Nos. 22 and 23) added.

TABLE VI.

Comparison of the Angles of Position, computed from the New Approximate Elements of ξ Ursae Majoris, with Observation.

No.	Observer.	Epoch.	Observed Position.	Compute Position.	Difference.
1	Herschel I., ...	1781·97	143°·78	147°·37	+ 3°·59
2	Herschel I., ...	1802·09	97 ·52	98 ·53	+ 1·01
3	Herschel I., ...	1804·08	92 ·63	92 ·55	− 0·08
4	Struve, ...	1819·10	284 ·55	287 ·93	+ 3·38
5	Herschel II. and South, .	1823·29	258 ·45	259 ·20	+ 0·75
6	South, ...	1825·22	244 ·53	246 ·20	+ 1·67
7	Struve, ...	1827·27	228 ·27	231 ·63	+ 3·36
8	Dawes, ...	1832·27	196 ·72	195 ·13	− 1·59
9	Dawes, ...	1840·29	150 ·85	152 ·95	+ 1·10
10	Dawes, ...	1842·27	144 ·76	145 ·98	+ 1·22
11	Dawes, ...	1843·28	142 ·17	142 ·85	+ 0·68
12	Dawes, ...	1849·30	126 ·58	127 ·10	+ 0·52
13	Miller, ...	1852·13	122 ·28	120 ·87	− 1·41
14	Jacob, ...	1853·20	119 ·47	118 ·58	− 0·89
15	Dawes, ...	1854·36	115 ·87	116 ·12	+ 0·25
16	Dembowski, ...	1858·20	108 ·09	107 ·80	− 0·29
17	Dembowski, ...	1863·23	96 ·66	94 ·87	− 1·79
18	Engelmann, ...	1865·12	91 ·42	88 ·43	− 2·99
19	Dembowski, ...	1866·30	86 ·76	83 ·52	− 3·24
20	Dembowski, ...	1867·31	82 ·22	78 ·55	− 3·67
21	Dembowski, ...	1868·30	77 ·50	72 ·58	− 4·92 !
22	Dembowski, ...	1870·24	57 ·74	56 ·10	− 1·64
23	Dembowski, ...	1871·22	47 ·70	43 ·80	− 3·90
24	Brünnow, ...	1872·28	24 ·19	26 ·47	+ 2·28

We must probably look for the final correction of the elements to observations which will be made during the next ten years.

To facilitate the comparison of the approximate elements now presented with observation, an ephemeris of the position angle has been computed. The ephemeris gives the position angle, at intervals of three months, from 1872·50 to 1878·75. The greatest velocity of change in the angular position occurs about 1873·25. At this date the rate will be fully 20° per annum. The periastron passage takes place about 1876·28, thus the period included in the ephemeris contains the most critical part of the entire orbit.

TABLE VII.

Ephemeris of the Angle of Position of the Binary Star ξ Ursae Majoris, computed from the New Approximate Elements.

No.	Epoch.	Computed Position.
1	1872·50, A.D.	22°·4
2	·75	17 ·5
3	73·00	12 ·5
4	·25	7 ·3
5	·50	2 ·2
6	·75	357 ·2
7	74·00	352 ·1
8	·25	347 ·0
9	·50	342 ·2
10	·75	337 ·6
11	75·00	333 ·2
12	·25	329 ·0
13	·50	325 ·1
14	·75	321 ·4
15	76·00	317 ·9
16	·25	314 ·7
17	·50	311 ·6
18	·75	308 ·6
19	77·00	305 ·8
20	·25	303 ·2
21	·50	300 ·7
22	·75	298 ·4
23	78·00	296 ·1
24	·25	293 ·9
25	·50	291 ·8
26	·75	289 ·7

XXXVII.—A SYNOPSIS OF THE MOSSES OF IRELAND. BY DAVID MOORE, PH. D., F. L. S., M. R. I. A.

[Read 24th. June, 1872.]

IN offering to the Academy the present synopsis of Irish Bryology, I have to observe that the muscological department of our flora has not been suffered to lag behind the other cryptogamic sections, but has rather been kept in advance of them. Two complete works on the subject have appeared in which all the species are described which were known at the respective periods of their publication to inhabit Ireland. The first of these books, written by Dawson Turner, was published in 1804, with the title of "Muscologiæ Hibernicæ Spicilegium;" the second, by the illustrious muscologist, Dr. Thomas Taylor of Kenmare, who in 1836 contributed the second part of Mackay's "Flora Hibernica," containing the Mosses, &c. In 1855 the late William Wilson, of Warrington, published his classical "Bryologia Britannica," in which he notices as Irish, some species not included by Dr. Taylor in his work, but which the author had found when examining the herbaria of Dawson Turner and Sir William Hooker, to whom these plants had been sent by the late Miss Hutchins of Bantry, whose name is well known to all cryptogamic botanists both here and abroad. About the period when that lady contributed so many novelties from Ireland to the late Sir James Smith, for his "English Botany," as well as to Dawson Turner and Hooker, there were a number of bryologists in this country. In the preface to the "Spicilegium," Dawson Turner mentions Dr. Robert Scott, then Professor of Botany in Trinity College, Dublin; Dr. Whitley Stokes, Fellow of Trinity College, Dublin; and John Templeton, of Belfast, as gentlemen from whom he had received contributions towards his work. He also quotes Dr. Wade, Professor of Botany to the Royal Dublin Society, as the discoverer of *Buxbaumia aphylla*, a rare and very curious moss, which is figured in the "Transactions of the Royal Dublin Society," vol. iv., 1804, but has not been rediscovered in Ireland since Wade's time. I know further that Dr. Francis Barker paid considerable attention to Mosses, and communicated his observations to Mr. Mackay and Dr. Whitley Stokes. In 1829 Mr. Wilson, the distinguished author of "Bryologia Britannica," paid a long visit to Ireland, for the purpose of investigating the Mosses, &c., of the Southern counties, where he collected a number of kinds not previously known as Irish, and also detected several species new to science, some of which he had figured and described in the Supplement to "English Botany," and other works. At a somewhat earlier period Mr. Thomas Drummond, who was Curator of the Botanic Gardens at Cork (when that establishment was extant), and a good muscologist, added a considerable number of rare and some new species, which are included by Dr. Tay-

lor in the "Flora Hibernica." In 1845, the "Contributions to the Flora and Fauna of the County of Cork" was published, in which Dr. Power gives a full list of the Mosses known to him as natives of that county. This list contains 173 species, six of which had not been previously noticed by Dr. Taylor. Again, in 1856, an important list of "New or scarce Irish Mosses found chiefly in the County of Cork," was published by Isaac Carroll, in the "Phytologist" for that year, vol. i., p. 236. He records fifty-seven species, and claims twenty-two of them as not having been before recorded as Irish. Among those who have studied Irish Muscology, though they have not published many of their observations, I may mention Dr. Thomas Alexander, of Cork, who investigated the Muscology of the neighbourhood of that city, and some of the results are published in the "Contributions to Flora and Fauna of Cork." Mr. David Orr, my assistant in the Botanic Garden, Glasnevin, has assiduously and successfully collected Mosses for many years, and has been the first to discover several rare kinds, which will be found recorded in their proper place. Dr. Dickie, formerly Professor of Botany in the Queen's College, Belfast, now of Aberdeen University, paid considerable attention to the Mosses of the North of Ireland, and discovered many new habitats of the rarer species. Mr. George E. Hunt of Manchester, has frequently visited Ireland for the purpose of collecting Mosses and *Hepaticeæ*, and has distributed a large number of specimens of them. The only other contribution of any considerable extent to our moss flora which I have not made myself, is that by Dr. Carrington of Eccles, Lancashire, who in 1862 published his "Gleanings among the Irish Cryptogams," in the Transactions of the Botanical Society of Edinburgh, Vol. vii. The author states that he spent eleven weeks at Killarney and other parts of the South of Ireland, in 1861, investigating the cryptogamic plants of that portion of the country, which is well known to be by far the richest in Ireland. His published list of mosses then found, amounts to 119 species, including those for which he quotes me as authority, and among them is one which had not been previously noticed as Irish, namely,—*Sphagnum auriculatum*.

My own bryological researches have extended over the last thirty-five years, and some of the results have already been published by Taylor and Wilson in their books. From time to time I have also myself published my subsequent observations in the Proceedings of the Dublin University Zoological and Botanical Association, Proceedings of the Royal Dublin Society, and Proceedings of the Dublin Natural History Society. Thus it will be seen, that our moss flora has not been neglected; but these separate contributions are so scattered through different publications, that no foreigner or other person unacquainted with them, can form anything like an adequate idea of their extent. They can only judge from the latest full publication on the subject, which is the "Flora Hibernica" in 1836. In the present synopsis, I have endeavoured as far as possible to rectify the unsatisfactory state of

this department of our flora, by collecting from the scattered papers those species which are noticed in them as additions, along with several which I possess that are not yet published, and together with those in the old floras, referring each to its proper genus. In this way, I trust to offer to the Academy a full account of the Mosses of Ireland, so far as they are known up to the present time.

The species described by the late Dr. Taylor in "Flora Hibernica," amount to 229, while those which have been added since the publication of that work in 1836, up to the present time, are 140 species, these being rather more than one third of the mosses now known to be natives of Ireland.

In the present essay I have endeavoured to arrange our Irish Mosses in Sub-orders and Tribes according to the latest knowledge of the subject, and in so doing I have followed, as being the simplest, and probably the best which has yet appeared, the plan adopted by Mr. Mitten in his "*Musci Austro-Americani,*" published in the Journal of the Linnean Society, vol. xii., 1869.

Mr. Mitten's arrangement differs considerably from those employed by previous writers on the subject. In the first place, the two great divisions of *Acrocarpi* and *Pleurocarpi* which have been so long in use by Muscologists have been discontinued, and three other divisions substituted, these being founded upon the structure of the peristome, which affords better defined characters than any other parts of the plant. Secondly, the group *Cleistocarpi*, e. g. *Phascum*, &c., of authors, which have generally been considered to form a section separate from the operculate mosses, has been abolished as unnatural, and the species which composed it have been distributed among the tribes to which they have most natural affinity.

In describing the genera and species, I have first given a brief diagnosis of each, and separately, the principal synonyms under which they have from time to time been designated by authors, followed by the habitats of the rarer kinds, and notices of their distribution through Ireland, as far as I have been able to ascertain it.

SUB-ORDERS AND TRIBES.

Sub-order I. STEGOCARPI. Capsule opening by transverse separation at the medial line; upper portion caducous, rarely persistent.

HOMODICTYI. Leaves composed of cells uniform in structure.

1. *Elasmodontes.* Peristome of the capsule, with four narrow teeth composed of confluent membranous cells.

Tribe 1. TETRAPHIDEÆ.

2. *Arthrodontes.* Peristome of the capsule with 8 teeth in pairs; 16-32-64, variously cleft, and composed of a double stratum

of cells. The outer coloured, the inner hyaline; sometimes an internal membranous peristome is present.

A. *Leaves in horizontal planes rarely vertical.*

a. *Stems erect or procumbent. Fruit terminal on the main stem, or more rarely terminal on short lateral branches.*

* *Male flowers gemmiform.*

Tribe 2. DICRANEÆ.
,, 3. GRIMMIEÆ.
,, 4. LEUCOBRYEÆ.
,, 5. TRICHOSTOMEÆ.
,, 6. ORTHOTRICHEÆ.

** *Male flowers in discoid heads.*

Tribe 7. FUNARIEÆ.
,, 8. SPLACHNEÆ.
,, 9. BARTRAMIEÆ.
,, 10. BRYEÆ.

aa. *Stems creeping; fruit lateral from the main stem, or from short side branches.*

b. *Leaves, sometimes as many as ten-ranked.*

Tribe 11. HOOKERIEÆ.

bb. *Leaves spreading equally, or compressed, disposed more or less in diverse series.*

Tribe 12. NECKEREÆ.
,, 13. STEREODONTEÆ.
,, 14. HYPNEÆ.

B. *Leaves expanded distichously in two planes.*

Tribe 15. SKITOPHYLLEÆ.

3. *Nematodontes.* Teeth of peristome of capsule composed of filaments, sometimes free, or with teeth-like processes connected at their apices, or into a folded membrane.

Tribe 16. POLYTRICHEÆ.
,, 17. BUXBAUMIEÆ.

HETERODICTYI. Leaves composed of cells diverse in form, and also differing in the nature of their contents, some being chlorophyllous and narrow, others with spiral or annular filaments.

Tribe 18. SPHAGNEÆ.

Sub-order II. SCHISTOCARPI. Capsule opening by longitudinal fissures at its sides, the segments cohering at their apices.

Tribe 19. ANDREÆEÆ.

ANALYSIS OF TRIBES AND GENERA.

Tribe 1. TETRAPHIDEÆ.

Perennial or annual mosses, growing gregariously on dry banks or moist shady rocks; stems slender, simple or dichotomous. Capsules pedicellate, oblongo-cylindrical, slightly reticulated; operculum slender, conico-elongated; calyptra mitriform, ribbed, lacerated at the base. Peristome of 4 teeth. Leaves ovate, lanceolate, or ovate-subulate, upper ones larger and more or less spreading; areolations roundish, or obtusely angular. Inflorescence monoicous.

Genera.

Calyptra mitriform, plicate, lacerated at base, 1. TETRAPHIS.

Calyptra submitriform, large, nearly covering the capsule, ... 2. TETRODONTIUM.

Tribe 2. DICRANEÆ.

Small mosses with stems more or less robust growing in lax or dense tufts, the lower portion frequently matted together. Leaves lax or densely crowded, spreading equally, secund or falcate-secund, often rigid and shining with a silky lustre; alar cells at base frequently turgid and conspicuous. Fruit terminal on main stems or on elongated branches; capsules entire or operculate. Peristome of the latter single, of 16 teeth, variously cleft, mostly to the middle or base into 32 filiform processes.

Sub-tribe 1. BRUCHIEÆ. Capsule without a deciduous lid.

Calyptra cleft on one side; leaves setaceous, pale green; shining; capsules nearly sessile among the perichætal leaves, . 3. PLEURIDIUM.

Sub-tribe 2. DICRANOIDEÆ. Lid of capsule deciduous.

a. Teeth of peristome 16.

Genera.

Calyptra multifid at base, teeth of peristome short, truncate, and fugacious, . . . 4. BRACHYODUS.

Calyptra cuculliform; teeth of peristome, lanceolate acute,. . . . . . . 5. SELIGERIA.

Teeth of peristome, short, broad, and bifid.

Calyptra not inflated, areolation of leaves nearly rectangular at base, . . . 6. DICRANELLA.

Teeth of peristome deeply cleft in filiform processes; calyptra cuculliform; capsule striated, swollen at the neck into a short struma, ... 7. CERATODON.

Teeth of peristome entire; capsule oval, striated, ... 8. RHABDOWEISSIA.

Teeth of peristome perforated; capsule without annulus, ... 9. BLINDIA.

Teeth of peristome connivent, irregular, fragile, ... 10. CYNODONTIUM.

Teeth split half way down, ... 11. ARCTOA.

Teeth slightly split, sometimes entire, . . 12. DICHODONTIUM.

Teeth, cloven half way down, into two unequal portions, ... 13. DICRANUM.

aa. Teeth of peristome, cloven nearly to the base into 32 divisions.

Calyptra fringed at the base, . . . 14. CAMPYLOPUS.

Calyptra not fringed at the base, . . . 15. DICRANODONTIUM.

Leaves distichous.

Teeth of peristome split into irregular segments, or entire, ... 16. DISTICHIUM.

Tribe 3. GRIMMIEÆ.

Perennial mosses, with more or less elongated stems, having dichotomous or fastigiate branches, growing gregariously or in close tufts. Leaves short and persistent, not rarely with hyaline or piliferous points; areolation dense and dot-like. Peristome single, of 16 teeth, variously perforated or cleft into two or three segments.

Genera.

Calyptra small conico-subulate, setæ, geniculate, ... 17. CAMPYLOSTELIUM.

Calyptra mitriform, lobed at the base, . . 18. GRIMMIA.

Calyptra, small, not extending to the mouth of capsule, lacerated or entire at base, . 19. SCHISTIDIUM.

Calyptra mitriform, plicate, nearly covering the capsule, ... 20. GLYPHOMITRIUM.

Calyptra mitriform, deeply furrowed, . . 21. PTYCHOMITRIUM.

Calyptra with subulate rough beak, membranaceous and multifid at base, . . 22. RACOMITRIUM.

Tribe 4. LEUCOBRYEÆ.

Pale, whitish, glaucous mosses, growing in dense masses, with dichotomously branched stems. Leaves soft, pale, white-coloured, consisting of two or more layers of large pellucid cells, among which are intercellular chlorophyllose passages. Fruit terminal from the stems or branches; capsule erect or inclined; peristome single of 16 bifid teeth.

One genus. . . . . 23. LEUCOBRYUM.

Tribe 5. TRICHOSTOMACEÆ.

Mosses growing in close tufts, gregarious or scattered. Stems usually more or less erect, rarely creeping. Leaves spathulate, linear-lanceolate or linear-subulate, with nerves, which are sometimes excurrent into piliferous denticulated points; areolation roundish, lax or dense, lower cells often large, pellucid, and more linear. Fruit terminal, rarely lateral; capsule operculate or solid; peristome wanting, or single of 16-32 teeth, often filamentous, more or less combined at base, or more or less spirally twisted.

Genera.

a Fruit terminal.

Sect. 1. *Phasceæ.*

Operculum persistent, not caducous.

Calyptra small, conical, split on one side or cuculliform. . . . . 24. PHASCUM.

Calyptra conico-campanulate, entire, . . 25. SYSTEGIUM.

Sect. 2. *Weissieæ.*

* Peristome none.

Calyptra cucullate beaked, extending below the operculum, ... 26. GYMNOSTOMUM.

Calyptra smooth or rough at apex, long persistent, ... 27. POTTIA.

** Peristome of 16 single teeth.

Teeth simple, equidistant lanceolate, . . 28. WEISSIA.

Sect. 3. *Trichostomeæ.*

Teeth narrow, acicular, rather long, . . 29. SPLACHNOBRYUM.

*** Peristome of 16-32 teeth in pairs.

Teeth without a basilar membrane, . . 30. DIDYMODON.

Teeth split to the base so as to resemble 32, connected by a narrow basilar membrane, . 31. TRICHOSTOMUM.

Peristome as in Trichostomum. Leaves more or less embracing at base, . . . 32. DITRICHUM.

Teeth of peristome more or less spirally twisted and confluent into a membranous tube at the base, ... 33. TORTULA.

aa Fruit more or less lateral.

Sect. 4. *Encalypteæ.*

Peristome wanting, ... 34. ANŒCTANGIUM.

Calyptra mitriform, inflated, entire, or cut at base, ... 35. ENCALYPTA.

Sub-tribe RIPARIEÆ.

Calyptra conico-attenuate, split at the side, connected below by anastomosing processes, 36. CINCLIDOTUS.

Tribe 6. ORTHOTRICHEÆ.

Mosses growing for the most part in close cushion-like tufts, with fastigiate more or less erect stems, rarely creeping. Fruit terminal from the main stems, or from the points of dichotomous shoots. Leaves many-ranked, varying from ligulate to lanceolate or linear-lanceolate; areolation dense in upper portion of leaf, cellules roundish, papillate, lower cells large, pellucid and elongate. Capsules more or less pedicellate or sub-immersed among the leaves, 8, or rarely 16-furrowed. Peristome single or double, the outer peristome of 8–16 teeth in pairs, which on separating appear as 32; inner of 8-16 equal cilia, or of 16 alternately shorter ones. Calyptra large, mitriform, more or less plicate, smooth or hairy.

Genera.

Calyptra mitriform, sulcate; inner peristome of 8–16 cilia, ... 37. ORTHOTRICHUM.

Calyptra cucullate, dimidiate; inner peristome of 8 cilia, ... 38. ZYGODON.

Tribe 7. FUNARIEÆ.

Mosses with short erect stems, fertile from the apex or subsequently, from the apices of branches. Leaves two or three-ranked broad, ovate or obovate-acuminate; areolation lax, composed of slender, hexagonal or rhomboidal cellules. Capsule obliquely pyriform, spherical or clavate, with or without a deciduous lid. Peristome when present single or double, of 16 teeth; inner peristome a

membrane divided into 16 acute processes, opposite to the outer teeth. Calyptra small or large and inflated. Inflorescence monoicous (Synoicous in Bartramidula); male flowers at the apices of short lateral branches.

Genera.

Sect. 1. *Phasceæ.*

* Capsule entire without a deciduous lid.

Calyptra broadly conical. Capsule ovate, . 39. EPHEMERUM.

Calyptra conic-campanulate, entire; capsule globose apiculate, ... 40. PHYSCOMITRELLA.

Calyptra small, erect, covering the apex of capsule only, ... 41. SPHÆRANGIUM

Sect. 2. *Pottieæ.*

** Capsule Gymnostomous.

Calyptra mitriform, cleft and inflated below; capsule pyriform, ... 42. PHYSCOMITRIUM.

Calyptra small cucullate, fugacious; capsule subspherical pendulous, . . . 43. BARTRAMIDULA.

Sect. 3. *Funarieæ.*

*** Capsule with peristome of 16 teeth.

Calyptra cucullate cleft and inflated; peristome single of 16 teeth, . . . 44. ENTOSTHODON.

Calyptra inflated; peristome double of 16 outer teeth; inner of 16 acute processes, . 45. FUNARIA.

Tribe 8. SPLACHNEÆ.

Small mosses, growing for the most part on animal substances, with thickish dichotomous fleshy stems. Leaves broad, of soft texture, or slightly rigid; areolation large and lax. Capsule oblong or sub-cylindrical, with a large fleshy vescicular apophysis of a different colour from the capsule. Peristome single of 8–16 teeth in pairs or very close together, reflexed when dry, incurved when moist. Calyptra small, entire, or cut at base. Inflorescence monoicous or dioicous.

One Irish genus, ... 46. SPLACHNUM.

Tribe 9. BARTRAMIEÆ.

Mosses with stems short or robust, decumbent at base; branches fasciculate or verticillate. Leaves frequently acute, with excurrent

nerves; areolation for the most part small and quadrate in upper portion of leaf, larger, more lax and pellucid below. Capsules large, globose or subspherical, smooth or sulcate. Peristome normally double, of 16 equidistant teeth; inner peristome a membrane divided into 16 lanceolate processes, alternating with the outer teeth. Calyptra small, dimidiate, or cucullate. Inflorescence synoicous, monoicous or dioicous.

One Irish genus, ... 47. BARTRAMIA.

Tribe 10. BRYEÆ.

Mosses with stems erect or decumbent at the base, simple or dichotomously branched. Leaves spreading regularly, rarely irregular; areolation large in most instances, cellules rhomboidal or elongate. Capsules on long erect or decurved pedicells, oblong, pyriform, clavate or oblique, erect or pendulous. Peristome double, outer of 16 teeth; inner of a membrane divided into 16 ciliary processes, alternating with the outer teeth; or with peristome less perfect in the shortness or deficiency of the inner cilia. Calyptra small, fugacious, conoid or cucullate. Inflorescence synoicous, monoicous or dioicous.

Genera.

Peristome double, more or less perfect; male flowers rarely discoid, ... 48. BRYUM.

Leaves dotted; capsule oblong, sulcate when dry, ... 49. AULACOMNIUM.

Plants annual; capsule pyriform, pendulous, . 50. LEPTOBRYUM.

Capsule oblong; male flowers discoid, . . 51. MNIUM.

Calyptra sub-inflated at base; leaves loosely reticulated, ... 52. AMBLYODON.

Tribe 11. HOOKERIEÆ.

Mosses with procumbent, decumbent, or suberect stems, dichotomous, irregular, or subpinnately branched. Leaves mostly complanate, variously-ranked, sometimes as many as 8 (10 Mitten), spreading laterally, with single and double nerves, the intermediate leaves appressed and often differently formed: areolation rather large, cellules elongate or rhomboid, smooth or papillate. Capsules springing from the main stem or lateral branches, on long or short pedicels, erect, or horizontally inclined; lid rostrate. Peristome double, outer of 16 teeth, which are sometimes marked externally with prominent ridges; inner peristome a membrane divided into 16 processes, without intermediate cilia. Calyptra multifid at base.

Genera.

Calyptra fringed at base, ... 53. DALTONIA.
Calyptra not fringed at base, ... 54. HOOKERIA.

Tribe 12. NECKEREÆ.

Mosses with rigid creeping stems, more or less pinnately branched. Leaves spreading equally or complanate, mostly with single or double short nerves. Fruit from the sides of upper branches, or from their apices. Capsules pedicellate or immersed among the perichætial leaves. Peristome sometimes wanting; inner cilia simple or none.

Genera.

Sub-tribe. 1. CRYPHÆEÆ. Leaves on fertile branches spreading equally.

Calyptra conical, small. Male flowers axillary, . 55. HEDWIGIA.
Calyptra cucullate. Male flowers terminal, . 56. HEDWIGIDIUM.
Calyptra coriaceous, smooth; fruit lateral, . . 57. LEUCODON.
Calyptra cuculliform; capsules on short pedicels, . 57*. ANTITRICHIA.
Calyptra large; setæ short, curved; fruit immersed among the perichætial leaves, . . . 58. CRYPHÆA.

Sub-tribe 2. METEOREÆ. Leaves spreading equally, two or three-ranked, compressed and sometimes bifarious, . 59. FONTINALIS.

Sub-tribe 3. EUNECKEREÆ. Leaves compressed or complanate, often unequally distichous.

Calyptra cut or dimidiate; capsules more or less immersed among the perichætial leaves, . 60. NECKERA.
Calyptra dimidiate; leaves not undulated, . . 61. HOMALIA.

Tribe 13. STEREODONTEÆ.

Mosses with creeping, procumbent or ascending stems, irregularly or pinnately branched. Leaves compressed or spreading equally, shortly binerved or nerveless; areolation narrow, alar-cells shorter. Fruit springing from stem. Inner peristome of solid processes, rarely perforated, cilia none, or imperfect.

Genera.

Leaves soft pale, subcomplanate; capsule cylindrical, cernuous, ... 62. PLAGIOTHECIUM.
Leaves membranous, shining when dry, alar-cells large and pellucid; capsule erect, . 63. CYLINDROTHECIUM.

Tribe 14. HYPNEÆ.

A very extensive tribe of mosses, small or robust, with creeping stems, irregularly or subpinnately branched. Leaves and other parts of the plants very variable, which renders it necessary to divide them into sub-tribes, and lesser natural groups.

Sub-tribe 1. ISOTHECIEÆ. Capsules mostly erect and symmetrical.

Genera.

Leaves spreading or subsecund, not striated; inner peristome 16 short membranous processes, slightly adherent to outer teeth, 64. PTERIGONIUM.

Stems more or less dendroid; inner peristome a membrane cut into 16 carinated processes, with intermediate cilia, . . 65. ISOTHECIUM.

Stems dendroid; inner peristome of 16 processes; longer than the teeth, and alternating with them, ... 65*. CLIMACIUM.

Peristome double; interior of 16 cilia, rising from a plicated base, ... 66. HOMALOTHECIUM.

Stems creeping; peristome double; inner cilia rising from a short basilar membrane, interruptedly cleft along their keels, ... 66*. PYLAISIA.

Sub-tribe 2. THUYIDIEÆ. Capsules more or less cernuous.

Stems dendroid, rhizomatous at their base, . 67. THAMNIUM.

Stems prostrate, radiculose, slightly villous; inner peristome with filiform processes between each of its segments, . . 67*. HETEROCLADIUM.

Interior peristome consisting of teeth longer than those of the outer, irregularly divided along their keels, ... 68. MYURELLA.

Peristome double; the exterior teeth trabeculated; those of the interior rising from a basilar membrane, and as long, or longer, than the outer teeth, ... 68* LESKEA.

Leaves yellowish-green; areolæ dense; inner peristome of 16 short fragile processes, 69. ANOMODON.

Stems villous; leaves papillose; outer peristome of 16 teeth, confluent at the base; inner of slender truncate cilia, . . 69* THUYIDIUM.

Sub-tribe. 3. CAMPTOTHECIEÆ.

Inner peristome a plicate membrane, divided half way into carinate cilia; ciliolæ present, 70. HYPNUM.

Tribe 15. SKITOPHYLLEÆ.

Mosses growing more or less gregariously, with ascending or erect stems, sometimes prostrate in marshy places. Leaves distichous, equitant at the base, or conduplicate, the upper part vertically prolonged into a scalpelliform leaf, with or without cartilaginous thickened borders; areolation dense, cellules roundish or hexagonal. Fruit terminal or lateral; capsules on long or short pedicels, often cernuous, variously shaped, sometimes short and truncate. Peristome single, of 16 teeth, cloven half-way down, rarely solid or joined in 8. Calyptra small, cucullate or dimidiate.

One genus, ... 71. FISSIDENS.

Tribe 16. POLYTRICHEÆ.

Mosses with stems of a peculiar rigid habit, simple, or branching from a creeping underground rhizome, growing gregariously, often in very large masses together. Leaves spreading regularly, mostly 5–8 ranked; nerve broad, and lamellated; areolation dense. Capsule smooth or angular. Peristome of 16–64 teeth, adherent by their points to the top of the columella. Calyptra dimidiate, smooth or hairy. Male flowers discoid.

Genera.

Leaves thickened at margin; calyptra smooth, slighly spinulose at apex, ... 72. CATHARINEA.

Leaves not thickened at margin, ... 73. OLIGOTRICHUM.

Calyptra hairy; capsule smooth, or indistinctly plicate, ... 74. POGONATUM.

Capsule strongly angular, ... 75. POLYTRICHUM.

Tribe 17. BUXBAUMIEÆ.

Mosses stemless, or with very short stems, growing singly or gregariously on the ground or on decayed wood. Leaves few, short and broad, nerved or nerveless; areolation lax or dense. Capsules large oblique, gibbous underneath. Peristome double, outer of short rudimentary teeth; inner a conical membrane, plicated into 16 plicæ. Calyptra small conico-mitriform.

Genera.

Capsule pedicellate, ... 76. BUXBAUMIA.

Capsule sessile, ... 77. DIPHYSCIUM.

Tribe 18. Sphagneæ.

Mosses growing on turbaries, barren moors, or very moist ground; with erect or decumbent simple or forked stems, and fascicled branches, spirally disposed on the stems. Leaves 5-ranked, obliquely inserted on the main stem, more crowded on the branches, nerveless; areolation reticulated, larger cellules perforated with minute pores, communicating with each other by intercellular pores, and lined with spiral or annular filaments; Capsules, globular and sessile from the centre of an upper fascicle of branches; the perichætal leaves ultimately elongating, and presenting the appearance of a lateral branch. Peristome wanting. Calyptra surrounding the ripe capsule, ruptured in the middle, the lower portion persistent, attached to the apex of the vaginula. Male flowers globose antheridia, inserted among the leaves at the apices of the branches.

One genus, ... 78. Sphagnum.

Tribe 19. Andreæeæ.

Mosses growing in close tufts or densely gregarious; with short stems, erect or decumbent at the base, branched in a dichotomous or fastigiate manner. Leaves imbricated, ovate-lanceolate, or subulate, of a purplish brown colour, nerved or nerveless; areolation dense and dot-like. Fruit terminal; capsule 4-cleft at the sides, or 5-valved, at first immersed among the perichætal leaves, often shortly exerted. Calyptra mitriform, thin and fugacious, closely covering the capsule.

One genus, ... 79. Andreæa.

DIAGNOSIS OF GENERA AND SPECIES.

Tribe 1. Tetraphideæ.

1. Tetraphis *Hedw.*

Setæ terminal. Peristome single, with 4 teeth, equidistant, erect, striated on the back. Calyptra mitriform, irregularly plicate and lacerate at base. Male flowers terminal.

1. *T. pellucida* (Hedw.). Species Musc., tab. 7, f. 1, Engl. Bot., tab. 1020. Bryol. Brit. p. 86, tab. 8.

Hab. Dry banks at Lough Bray, Wicklow. Abundant at Cromagloun, Killarney; and at O'Sullivan's cascade, fruiting in September. Benbulben, Sligo. Glenariff, Antrim.

Rather a rare Moss in Ireland, particularly so in a fruiting state.

2. TETRODONTIUM *Schwægær.*

Capsule as in Tetraphis, only the teeth are shorter. Plant minute, with very short stems, bulb-like at the base, producing a few small ovate-lanceolate leaves, and sometimes slender flagelliform branches.

1. *T. Brownianum* (Dicks.). Bryol. Brit., p. 195, tab. 8. Tetraphis Browniana, Muscol. Brit., Ed. 2, p. 33, tab. 1. Greville, Scot. Crypt. Fl., tab. 169. Grimmia Browniana, Engl. Bot., tab. 1422.

Hab. Shady rocks in a ravine near the head of Kelly's Glen, Dublin. In a glen near Ballycastle, Antrim, in fine fruit, July, 1835. Dry, shaded rocks at Lough Bray. Flor. Hib.

This singular and very minute Moss is rare in Ireland, though it may be occasionally overlooked, owing to its smallness and the places where it grows.

Tribe 2. DICRANEÆ.

Sub-tribe 1. BRUCHIEÆ. *Lid of capsule adnate not separating.*

3. PLEURIDIUM. Schimp.

Plants small; stems short; leaves subulate setaceous; areolation oblong hexagonal, cells rather large and loose; capsule globular; lid not separating; calyptra conic campanulate.

* Inflorescence monoicous.

Leaves lanceolate, nerve vanishing below the apex, ...	1. P. NITIDUM.
Leaves subulate, nerve reaching to the apex, .	2. P. SUBULATUM.
Leaves subulate, Male flowers gemmiform, .	3. P. ALTERNIFOLIUM.

1. *P. nitidum* (Hedw.). Rabenhorst Bryothec Europ. No. 153. Bryol. Europ., Coroll., p. 6, tab. 9, P. axillare, Lindberg, "De muscis cleistocarpis," Helsingfors, 1863. Phascum nitidum, Bryol. Brit., p. 36, tab. 4, P. axillare, Muscol. Brit. Ed. 2, p. 7, tab. 5.

Hab. Moist banks near Belfast, Templeton. Near Rathpeacon and Ballynoe, Cork Flor., Cork. Ballincollig Castle, Cork, Isaac Carroll.

2. *P. subulatum* (Schimp.), Bryol. Europ., vol. I. tab. 9, Coroll., p. 6, Phascum subulatum (Linn.), Engl. Bot., tab. 2177. Muscol. Brit. Ed. 2, p. 6, tab. 5.

Hab. Clay banks, pasture fields, and shady banks, in many parts of Ireland.

3. *P. alternifolium* (Bruch et Schimp.). Bryol. Europ. vol. I. tab. 10, Coroll, p. 6, Phascum alternifolium, Bryol. Brit., p. 35, tab. 37. Muscol. Brit., ed. 2, p. 5, tab. 5.

Hab. Banks and fallow ground, near Bantry, Miss Hutchins; Dunkerron, Taylor in Flor. Hib.

Sub-tribe 11. DICRANOÏDEÆ. *Capsule opening, lid deciduous.*

4. BRACHYODUS. Nees et Hornsch.

Plants small; stems gregarious and slender. Leaves subulate setaceous. Peristome single of 16 short truncate teeth, pale and fugacious, scarcely reaching above the broad annulus. Inflorescence monoicous.

1. *B. trichodes* (Nees et Hornsch). Bryol. Germ. tab. 25. Weissia trichodes, Muscol. Brit., Ed. 2, p. 83, tab. 15. Grimmia trichodes, Engl. Bot., tab. 2563.

Hab. On rocks of granite and sandstone. Near Lough Bray; Taylor in Flor. Hib. Kelly's Glen, Dublin, on the shady side of granite rocks near the stream, in fruit, May, 1863.

This species is rare in Ireland, and hitherto only known in the granite districts of Wicklow and Dublin.

5. SELIGERIA. Bruch et Schimp.

Plants small, almost stemless. Leaves lanceolate subulate; areolation dense, the basal cells larger. Peristome single, of 16 obtuse teeth, without a medial line; operculum large obliquely rostrate. Inflorescence dioicous.

Diagnosis of Species.

Pedicel straight; lid of capsule obliquely rostrate, ... 1. S. PUSILLA.
Pedicel recurved; lid of capsule straight, . 2. S. RECURVATA.

1. *S. pusilla* (Br. et Sch.). Bryol. Europ., vol. II. tab. No. 110, Bryol. Brit., tab. 15. Weissia pusilla (Hedw.) Muscol. Brit. Ed. 2, p. 86, tab. 15.

Hab. Sides of shady calcareous rocks. Near Belfast, at Wolf hill, above the mill, in considerable abundance on the white limestone rocks; fruiting, May, 1837. Also on shady limestone rocks above Lisburn, Antrim. This rare and pretty little Moss appears to be confined in Ireland to the white limestone rocks of Antrim.

2. *S. recurvata.* (Br. et Schimp.). Bryol. Brit., tab. 15. Weissia, recurvata Bridel., Bryol. Univ. 1, p. 332, Muscol. Brit., Ed. 2, p. 16, tab. 15.

Hab. On old red sandstone rock, Brandon, Co. Kerry. Taylor in Flor. Hib. Very rare in Ireland.

6. DICRANELLA. Schimp.

Plants small, stems gregarious. Leaves subulate or lanceolate-setaceous, serrulate at the apex; areolation uniform at base. Peristome single, of 16 bifid teeth. Capsule more or less cernuous. Inflorescence dioicous.

Diagnosis of Species.

* Leaves squarrose or spreading on each side of the axis, more or less crisped in drying.

Plants large, leaves squarrose, . . . 1. D. SQUARROSA.

** Leaves not squarrose, plants very small.

Monoicous, capsule erect, oval, striated, . 2. D. CRISPA.
Capsule cernuous, ovate, substriated, substrumose, ... 3. D. GREVILLEANA.
Dioicous, capsule gibbous, distinctly strumose, ... 4. D. CERVICULATUM.

*** Leaves turned to one side, more or less crisped in drying.

Capsule obliquely cernuous, not strumose, . 5. D. SUBULATUM.
Capsule obliquely furrowed, fruit stalk pale, 6. D. HETEROMALLUM.
Capsule oblong, slightly oblique and incurved, 7. D. VARIUM.
Capsule erect, ovate truncate, . . . 8. D. RUFESCENS.

1. *D. squarrosa* (Schimp.). Synops. Muscor., p. 71. Briol. Ital., p. 642. Dicranum squarrosum, Schräd. Journ.—Muscol. Brit., Ed. 2, p. 98. Bryol. Brit., p. 68, tab. 17.

Hab. In wet places by the sides of streams, and on wet banks. Of frequent occurrence in Ireland, but nowhere very common. It bears fruit in Kelly's Glen, Dublin.

2. *D. crispa* (Schimp.). Synop. Musc., p. 69, Rabenhorst, Bryothec. Europ., No. 49. Dicranum crispum, Hedw., st. cr. vol. II. tab. 32. Turner, Muscol. Hib., p. 65. Muscol. Brit., Ed. 2, p. 99. Bryol. Brit., p. 70, t. 17.

Hab. On moist banks in the more hilly parts of the country. Dunbullogue Glen, near Cork. (Mr. D. Murray), Fl. Cork. In fine fruit

on a steep bank, by the side of the river, about two miles from Maam Hotel, Connemara, Sept., 1854. Near Belfast, Templeton. Killarney, W. Wilson. Rare in Ireland.

3. *D. Grevilleana* (Schimp.). Synops. Muscor. Europ., 70. Briol. Ital., p. 640. Dicranum Grevilleanum, Bryol. Brit., p. 69, tab. 33. D. Schreberianum. Muscol. Brit., Ed. 2, p. 95.

Hab. Damp banks. The plant supposed to be this species (*fide* Wilson) was gathered from a gravelly wet bank on the side of Lugnaquilla mountain, Wicklow, in June, 1864, but not in fruit.

4. *D. cerviculata* (Schimp.). Synops. Muscor., p. 72. Dicranum cerviculatum Hedw., Turner. Muscol. Hib., 64. Muscol. Brit., Ed. 2, p. 93. Bryol. Brit., p. 72, tab. 16.

Hab. Turbaries and on moist banks, where the soil is of a peaty nature. Frequent through Ireland.

5. *D. subulata* (Schimp.). Synops. Muscor., 74. Dicranum subulatum (Hedw.), Muscol. Brit., Ed. 2, p. 103. Bryol. Brit., p. 73, tab. 18.

Hab. Moist banks. On the bank of the river in the valley between Connor hill and Brandon, Kerry, in fruit, October, 1860; Maryburn rivulet, near Belfast, Templeton; Great Island, Cork. (Dr. Scott), Flor., Cork. Rare in Ireland.

6. *D. heteromalla* (Schimp.). Synops. Muscor., p. 75. Dicranum heteromallum, (Hedw.). Turner, Muscol. Hib., p. 161. Muscol. Brit., Ed. 2, p. 103. Bryol. Brit., p. 73, tab. 18.

Hab. Banks and road sides. Frequent and widely distributed in Ireland.

7. *D. varius* (Schimp.). Synop. Muscor., p. 72. Briol. Ital., p. 639. Dicranum varium (Hedw.). Turner. Muscol. Brit., p. 65. Bryol. Brit., p. 71, tab. 17.

Hab. On moist sandy banks and by road sides. Of frequent occurrence in Ireland.

8. *D. rufescens* (Schimp.). Synop. Muscor., p. 74. Rabenhor., Bryothec. Europ., No. 266. Dicranum rufescens, Turner, Musc. Hib., p. 66.

Hab. Near Killarney. Lough Bray, Wicklow; and in Kelly's Glen, Dublin.

7. CERATODON. Bridel.

Capsule pedicellate, cylindrical, cernuous, with a short swollen or substrumose neck, annulate. Peristome single of 16 teeth, cloven nearly to the base, in two segments, connected below by transverse prominent articulations. Leaves lanceolate-subulate with dense roundish small areolation: the basal cells larger and diaphanous. Inflorescence dioicous.

This genus is placed among the Trichostomaceæ, by Lindberg, in his revision of that tribe.

Diagnosis of Species.

Capsule elliptic or subcylindrical, furrowed when dry, strumose at the base, . . 1. C. PURPUREUS.

Capsule cylindrical, sub-erect, or slightly curved, ... 2. C. CYLINDRICUS.

1. *C. purpureus* (Bridel.). Bryol. Univ. 1, p. 480. Didymodon purpureum, Muscol. Brit., Ed. 2, p. 113. Bryol. Brit., p. 84, tab. 20.

Hab. On dry banks, sand hills near the coast, and especially on heaths which have been recently burned. Very common everywhere through Ireland.

2. *C. cylindricus.* (Br. et Schimp.). Bryol. Europ., vol. II., tab. 192. Bryol. Brit., p. 85, tab. 39. Trichostomum cylindricum, Hedw. tab. 24. Didymodon cylindricum, Hook. in English Flora, vol. v.

Hab. On sandy banks near the Botanic Gardens, Belfast. T. Drummond. Not hitherto observed elsewhere in Ireland.

8. RHABDOWEISSIA. Br. et Schimp.

Capsule pedicellate, short, oval, 8-striated; lid rostrate. Peristome single of 16 lanceolate teeth, without medial line. Leaves linear-lanceolate, margins plane and nearly entire; areolation dense and somewhat quadrate. Inflorescence monoicous.

Diagnosis of Species.

Teeth of peristome fugacious subulate, . . 1. R. FUGAX.

Teeth of peristome more persistent, . . . 2. R. DENTICULATA.

1. *R. fugax* (Br. et Schimp.). Bryol. Europ., vol. I., tab. 41. Bryol. Brit., p. 50, tab. 15. Weissia striata var. minor, Hook. and Tayl. Muscol. Brit., Ed. 2, p. 81. Weissia fugax, Hedw.

Hab. Crevices of rocks, &c. Glenmalur and Powerscourt Waterfall, Wicklow; Connemara, Galway; Sillagh-braes, near Larne, Antrim; Benyevenagh, Derry.

2. *R. denticulata* (Br. et Schimp.). Bryol. Europ., vol. I., tab. 42. Bryol. Brit., p. 51, tab. 15. Weissia denticulata, Bridel., Bryol. Univer., 1, p. 342.

Hab. Crevices of subalpine rocks. Glenmalur and Upper Lough Bray, Co. Wicklow.

9. BLINDIA. Br. et Schimp.

Calyptra somewhat angular below, split on one side. Capsule longish-oval, of firm texture; annulus none. Peristome single, of 16 lanceolate teeth, more or less perforated and barred; stems slender and flexuose. Leaves acute, nerve broad; areolation dense, basal cells larger and quadrate. Inflorescence dioicous.

1. *B. acuta* (Br. et Schimp.). Bryol. Europ., vol. II., Monogr., p. 3, tab. 114. Bryol. Brit., p. 85, tab. 5. Weissia acuta, Hedw.

Hab. Dripping rocks and moist banks in subalpine places. This species occurs in most of the counties of Ireland.

10. CYNODONTIUM. Br. et Schimp.

Calyptra inflated, cuculliform. Capsule pedicellate, ovate-oblong; lid rostrate. Peristome single, of 16 teeth, which are confluent at base, entire or irregularly cleft and connected by transverse bars. Leaves more or less papillose, linear-lanceolate, spreading; areolation somewhat quadrate, the basal cells larger. Inflorescence monoicous.

1. *C. Bruntoni* (Br. et Schimp.). Bryol. Europ., vol. I., tab. 44. Bryol. Brit., p. 61, tab. 34. Dicranum Bruntoni, Engl. Bot., tab. 2509. Didymodon Bruntoni, Muscol. Brit., Ed. 2, p. 117.

Hab. Rocks in subalpine parts of the country. Waterfall at Powerscourt and near Seven Churches, Wicklow; Deer Park, Glenarm, Antrim; Glenbower and Kildorney, Cork; Isaac Carroll. Rare in Ireland.

11. ARCTOA. Br. et Schimp.

Calyptra cuculliform. Capsule shortly pedicellate, oval or turbinate, slightly ribbed; lid obliquely rostrate. Peristome single, of 16 teeth, cloven half way or perforated and entire. Leaves long lanceolate-setaceous, costate, falcate secund; areolation rather close and small. Inflorescence monoicous.

1. *A. fulvella* (Br. et Schimp.). Bryol. Europ., vol. I., Monogr., p. 4, tab. 86. Bryol. Brit., p. 59, tab. 33. Dicranum fulvellum, Engl. Bot., tab. 2268. Muscol. Brit., Ed. 2, p. 103.

Hab. On Macgillicuddy's Reeks, Kerry. Taylor. Flor. Hib.

12. DICHODONTIUM. Schimp.

Capsule on a long pedicel, ovate or obovate. Operculum conico-rostrate; annulus none. Peristome single, of 16 teeth, cleft to the middle and connected at base. Calyptra small, cuculliform, fugacious. Leaves imbricated, broadly acute or oblong; areolation dense, subquadrate. Inflorescence dioicous.

1. *D. pellucidum* (Schimp.). Synop. Muscor., p. 65. Briol. Ital., p. 489. Dicranum pellucidum. (Hedw.). Bryol. Europ., vol. i., Monogr. p. 16, tab. 50, 51. Bryol. Brit., p. 67, tab. 17. Turner. Muscol. Hib., p. 68.

Var. γ. D. flavescens, Eng. Bot., tab. 2263. Muscol. Brit,. Ed. 2, p. 98.

Hab. By the sides of rivulets and on wet rocks. Frequent in many parts of Ireland, especially in hilly districts. Var. γ. very fine on the limestone rocks at Benbulben, Sligo.

13. DICRANUM. Hedw.

Capsule oval oblong, or cylindrical, long pedicellate, erect or cernuous, the neck sometimes gibbous or apophysate. Peristome single, of 16 linear-lanceolate, equidistant teeth, joined at the base, cleft half way or more into equal segments. Calyptra cuculliform. Leaves lanceolate or lanceolate-subulate, costate and not rarely falcate-secund; areolation small and somewhat dot-like, except the marginal cells at the base, which are often large and quadrate. Inflorescence monoicous.

Diagnosis of Species.

* Capsule elongated, nearly erect.

Capsule nearly cylindrical, slightly curved, .	1. D. SCOTTIANUM.
Capsule oval, strumous when dry; annulus simple, ...	2. D. BLYTTII.

** Capsule more or less cernuous.

Leaves not undulated, ...	3. D. FUSCESCENS.
Capsule sub-erect, not furrowed; annulus none, ...	4. D. SCOPARIUM.
Capsule subcylindrical, subcernuous; lid with a long beak, ...	5. D. FLAGELLARE.
Capsule cernuous, incurved, furrowed when dry, ...	6. D. MAJUS.
Leaves undulated, ...	7. D. BONJEANII.

14. CAMPYLOPUS. Bridel.

Calyptra fringed at the base; setæ decurved; each from a separate perichœtum. Capsules aggregated, oval or gibbous, annulate, striated or slightly ribbed when dry; lid conic-rostrate. Peristome single, of 16 linear-lanceolate deeply bifid teeth, of rather unequal segments. Leaves rigid, lanceolate-setaceous, sometimes piliferous; areolation large, rhomboid-oblong, or subquadrate at the basal margin; smaller and closer above; nerve broad, sometimes excurrent. Inflorescence dioicous.

Diagnosis of Species.

"Leaves hoary at point, auricled at base, with enlarged alar cells, . . .	1. C. LONGIPILUS.
Leaves not auricled, nerve one third as wide as leaf base, hair point short, . . .	2. C. BREVIPILUS.
Nerve three-quarters as wide as leaf base, hair point longer, ...	3. C. INTROFLEXUS.
Stems short or long: leaves subulate, glossy yellow green, ...	5. C. FLEXUOSUS.
Margin of leaf serrulate above, . . .	6. C. SETIFOLIUS.
Margin of leaf entire, ...	7. C. SCHWARZII.
Nerve half as wide as leaf base, basal cells large and lax, ...	8. C. FRAGILIS.
Nerve one-third as wide as leaf base; lamina suddenly narrowed at one-fourth length of leaf,"	9. C. TORFACEUS.

1. *C. longipilus* (Bridel.). Bryol. Univ., 1, p. 477. Bryol. Brit., p. 90, tab. 40. Bryol. Europ., vol. I., Monogr., p. 6, tab. 93. Dicranum longipilum, C. Müller, Synop. Muscor., 1, p. 414. D. flexuosum, γ. piliferum. Turner, Muscol. Hib., p. 74. D. flexuosum, β. nigro-viride, Muscol. Brit., p. 94.

Hab. Turf bogs, wet rocks, and marshy places. Abundant in many parts of Ireland, especially about Killarney. Seven Churches, Wicklow. This species has never yet been found fruiting in Ireland. The stems vary from two to six inches in length.

2. *C. brevipilus* (Br. et Schimp.). Bryol. Europ., vol. I., tab. 92. Bryol. Brit., p. 81, tab. 40. Dicranum brevipilum, C. Müller, Synops. Muscor., vol. I., p. 412.

Hab. Bogs and wet banks, Howth, Dublin, David Orr. Kylemore, Connemara. Fruit unknown to me.

3. *C. introflexus* (Bridel.). Mont. Musc., p. 72. Mitten, Journal Linn. Soc., vol. XII., p. 72. C. polytrichoides. De. Notr., Syllab. Musc., p. 300.

Hab. On dry rocks, tops of turf walls, &c. Very fine on the top of a dry wall near the meeting of upper and lower lakes, Killarney. Also near the hunting lodge, Cromagloun. D. M. and Dr. Carrington. West of Ireland, with falcate leaves (found by Prof. Barker), Braithwaite, in "Journal of Botany," 1870.

4. *C. alpinus* (Schimp). Muscor. Europ. Nov., fasc. 1 et 2. C. intermedius, Wils. M. S. *fide* Braithwaite, in "Journal of Botany," p. 4. December, 1870.

Hab. Moist rocks and banks. Lough Bray and Powerscourt Waterfall, Wicklow: Kelly's Glen, Dublin; Cushendall, Antrim: Kylemore, Connemara. This plant is probably not uncommon in the more mountainous parts of the country. It is only of late years that it has been well understood.

5. *C. flexuosus* (Dill.). Bryol. Europ., vol. I., Monogr., p. 3, tab. 89. Bryol. Brit., p. 90, tab. 16. Dicranum flexuosum, Muscol. Brit., Ed. 2, p. 94.

Hab. Damp rocks and moist banks, especially in the more elevated portions of the country. Abundant on the rocks at Cromagloun and other places near the lakes of Killarney. Fair Head, Co. Antrim · near Kylemore, Connemara; Lough Bray, &c., Wicklow.

6. *C. setifolius* (Wils.). Bryol. Brit., p. 89, tab. 40. Schimp., Muscor. Europ. Nov., fasc. 3 et 4. Rabenhor., Bryothec. Europ., No. 1055.

Hab. On wet banks among grass and heath. Abundant at Cromagloun, Killarney; Gap of Dunloe, Schimper. Near the Waterfall at Powerscourt, Wicklow, and about the small lakes above Kylemore Castle, Connemara. Not found fruiting in Ireland.

7. *C. Schwarzii* (Schimp.). Musc. Europ., Nov. fasc. 1 et 2. 1864. C. auriculatus, Wils. M. S. Rabenhor., Bryothec. Europ., No. 935.

Hab. Soft boggy places at a considerable elevation on the mountains in South of Ireland. Very fine on Connor hill, near Dingle, Macgillicuddy's reeks, and near the top of Carrantuohil Mountain, Kerry: Muckish Mountain, Donegal, growing in large soft, silky patches.

8. *C. fragilis* (Br. et Schimp.). Bryol. Europ., vol. I. Monogr. p. 4, tab. 90. C. densus, Bryol. Brit., p. 88, tab. 40. Dicranum flexuosum, var. fragile, Turner. Muscol. Hib., p. 74.

Hab. Bogs, rocks, and shady banks. Near Bantry, in fruit, Miss Hutchins, 1808. Howth, D. Orr. Lough Bray, and Powerscourt, Wicklow; Gap of Dunloe, in fruit, 1865; Kylemore, Connemara. Cork, Isaac Carroll.

9. *C. torfaceus* (Br. et Schimp.). Bryol. Europ., vol. I., Monogr., p. 5, tab. 91. Bryol. Brit., p. 89, tab. 40. Dicranum flexuosum, Hedw., Sp. Muscor., tab. 28. Bryum fragile, Dickson, Fasc. 3, p. 5, *fide* Smith, in Engl. Bot., text to tab. 1491.

Hab. Shady banks among grass and heath, margins and sides of drains, cuts in deep turf bogs. Frequent in most parts of Ireland.

15. DICRANODONTIUM. Bruch et Schimp.

Calyptra cuculliform, not fringed at base. Capsule on an elongated arcuate pedicel, elliptic-oblong, smooth and thin in texture; lid conico-subulate. Peristome single, of 16 teeth, cloven to the base and trabeculate. Leaves subulate-setaceous, with broad prominent nerves; areolation narrow, larger at the base. Inflorescence dioicous.

1. *D. longirostre* (Br. et Schimp.). Bryol. Europ., vol. I., tab. 88. Bryol. Brit., p. 86, tab. 39. Didymodon longirostrum, Web. et Mohr. Dicranum flexuosum, Bridel., Bryol. Univ. 1, p. 111.

Hab. Shady banks and crevices of rocks. O'Sullivan's Cascade, and Cromagloun, Killarney; Glenmalur, Wicklow; Benbulben, Sligo. Barren in all these localities.

16. DISTICHIUM. Bruch. et Schimp.

Calyptra cucullate-rostrate. Capsule pedicellate, oval, or cylindrical, erect or cernuous. Peristome single, of 16 teeth, partially cloven and perforated. Leaves distichous, subulate-setaceous; areolation dense above, cells at base enlarged and diaphanous. Inflorescence monoicous. Distinguished chiefly by the distichous leaves.

Diagnosis of Species.

Capsule erect, ovate-oblong, . . . 1. D. CAPILLACEUM.

Capsule cernuous, or almost horizontal, . 2. D. INCLINATUM.

1. *D. capillaceum* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 4, tab. 193. C. Müller. Synop. Musc. 1, p. 40. Bryol. Brit., p. 104. tab. 20. Cynodontium capillaceum, Hedw. Sp. Muscor., p. 57. Trichostomum capillaceum, Engl. Bot., tab. 1152. Didymodon capillaceum, Muscol. Brit., p. 119.

Hab. Crevices of rocks in subalpine parts of the country. Benbulben, Sligo, in fine fruit, May, 1871; Lough Bray, and Glenmalur, Wicklow.

2. *D. inclinatum* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 5, tab. 194. Bryol. Brit., p. 105, tab. 20. Cynodontium inclinatum, Schwaegr. Suppl., p. 111. Didymodon inclinatum, Muscol. Brit., p. 115.

Hab. Rocks, and among the sand-hills on the coast of Connemara, Mackay. Benbulben, Sligo, and also on the sand-hills between Benbulben and the sea, in fine fruit, July, 1856; sandy banks between Killala and Ballycastle, Mayo. Rare in Ireland.

Tribe 3. Grimmieæ.

17. Campylostelium. Bruch. et Schimp.

Capsule pedicellate, oblongo-cylindrical; lid conico-subulate. Peristome single, of 16 long lanceolate teeth, trabeculated, and slightly cloven above, connected by a membrane rising as high as the mouth of the capsule. Calyptra 4–5 cleft at base. Leaves crowded at base of stem, elongate-lanceolate, slightly canaliculate; areolation small dot-like, basal cells much larger. Inflorescence monoicous.

C. saxicola (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 3, tab. 116, Schimp. Synop. Muscor., p. 688. Bryol. Brit., p. 52, tab. 13. Dryptodon saxicola, Bridel., Bryol. Univ. 1, p. 770. Grimmia saxicola, Muscol. Brit., Ed. 2, p. 67.

Hab. On granite rocks near Lough Bray, Wicklow, Taylor in Flor. Hib. This is one of the smallest of all our Mosses, and may be easily passed over; it is not, however, so rare among rocks in the granite districts of Wicklow and Dublin as has been supposed. I have gathered it in a good state of fructification, from February to April, on shady rocks, by the sides of the small streamlets falling from the high ground to the river in Kelly's Glen, Dublin; also near Lough Bray.

18. Grimmia. Ehrh.

Calyptra small, conico-mitriform or dimidiate. Capsule pedicellate, ovate, or nearly cylindrical. Peristome single, of 16 lanceolate teeth, more or less perforated and cribrose, rarely 2–3 cleft above. Leaves more or less imbricated, somewhat octofariously disposed on the stems; areolation dense and dot-like. Inflorescence monoicous or dioicous.

Sect. 1. *Pulvinatæ.* Wils.

Diagnosis of Species.

Inflorescence monoicous.

Stems densely tufted.

Capsules drooping, 8-furrowed, . . 1. G. PULVINATA.
Capsules faintly striated, orbicular, . . 2. G. ORBICULARIS.

Sect. 2. *Trichophyllæ.* Wils.

Inflorescence dioicous.

Stems either loosely or densely tufted.

Leaves, only the upper on stem hair-pointed, 3. G. SPIRALIS.
Leaves three-ranked, spirally twisted when dry, ... 4. G. TORQUATA.
Leaves lax, flexuose, gradually tapering to a hair point, ... 5. G. TRICHOPHYLLA.
"Leaves appressed when dry—erecto-patent when moist—lowest short and muticous from a slightly contracted ovate base becoming lanceolate; upper longer, gradually tapering into a nearly smooth hair point, one-third to half length of lamina, keeled at back with the strong nerve; margin recurved in the lower half; cells quadrate incrassate, those at centre of base elongated, above minute and irregular in outline; a single row at the margin of basal wing hyaline." Braithwaite, in "Journal of Botany," July, 1872, ... 6. G. ROBUSTA.
Leaves, elongate, lanceolate, the uppermost secund, ... 7. G. HARTMANNI.
Leaves crowded, lanceolate, subsecund, gradually tapering into a long rough diaphanous point, margins recurved. Inflorescence monoicous, . . . 8. G. SCHULTZII.

Sect. 3. *Elatiores.* Wils.

Leaves without piliferous points, spreading every way. Inflorescence dioicous, . 9. G. PATENS.

Sect. 4. *Leucophaeae.*

Calyptra conico-mitriform, lobed at the base; leaves shortly piliferous at their points; Inflorescence monoicous, . . . 10. G. OVATA.

Leaves with long white hair points. Inflorescence dioicous, ... 11. G. LEUCOPHAEA.

1. *G. pulvinata* (Smith). Engl. Bot., tab. 1728. Muscol. Brit., Ed. 2, p. 68.

Hab. On walls and rocks all over Ireland, from sea level to the tops of the highest mountains.

2. *G. orbicularis* (Br. et Sch.) Bryol. Europ., vol. III. Monogr., p. 13, tab. 240. Engl. Bot., Suppl., tab. 2888. Bryol. Brit., p. 154, tab. 45.

Hab On the faces of walls in warm situations. Near Cove, Cork, where it was pointed out to me by Isaac Carroll. On a wall by the side of the road leading to Dublin from Stillorgan. The tufts of this species are less compact than those of the former, and spread continuously, sometimes to a foot or more in breadth.

3. *G. spiralis* (Hook. and Taylor). Muscol. Brit., 69. G. spiralis, Greville, Scot. Crypt. Fl., tab. 233. Bryol. Europ., vol. III. Monogr., p. 14, tab. 242. Dryptodon spiralis, Bridel., Bryol. Univ. 1, p. 772.

Hab. On rocks in the subalpine parts of the country. Abundant on Slemish hill, and also at Sillagh-braes, near Larne, Antrim. Upper Lough Bray, Wicklow. On rocks by the sides of the lakes above Kylemore Castle, Galway. It has not been found with fruit in Ireland.

4. *G. torquata* (Greville). Scot. Crypt. Fl., tab. 199. G. torta, Nees et Hornsch. Bryol. Germ., tab. 24, fig. 24. Bryol. Brit., p. 156, tab. 32.

Hab. On moist rocks at elevations varying from 1000 feet above sea level to the tops of the highest mountains in Ireland. It is found in most of the counties where the hills attain that elevation, but always barren.

5. *G. trichophylla* (Greville). Scot. Crypt. Fl., tab. 100. Muscol. Brit., p. 68. Bryol. Brit., p. 156, tab. 32. Dicranum pulvinatum, var. argenteum, Turn., Musc. Hib., p. 78.

Hab. Not unfrequent on the Dublin and Wicklow Mountains. Very fine in fruit on rocks where the river is crossed going from Luggelaw to Lough Dan, Wicklow, May, 1861. On the rocks at Fair Head, Antrim.

6. *G. robusta* (Fergusson, M. S.). G. ambigua, Wils. M. S., *fide* Braithwaite, in "Journal of Botany," for July, 1872, (Pl. 124, Fig. 3).

Hab. Rocks in alpine districts. Fair Head, Antrim, 1862; Connemara, Galway, 1863. This fine species bears great resemblance to G. Schultzii, and W. Wilson named it as a variety of that species when I first sent it to him. He afterwards named it G. ambigua. There is considerable difference between the areolation and points of the leaves of the two.

7. *G. Hartmanni* (Schimp.). Synop. Muscor., p. 214. Braithwaite, in "Journal of Botany," July, 1872, (Pl. 124, Fig. 4).

Hab. Rocks and walls. On a wall built loosely of rough stones and rocks, between Cong and Moytura, Galway, April, 1872. Not hitherto observed elsewhere in Ireland?

8. *G. Schultzii* (Bridel.). Bryol. Univ. 1, p. 199. G. Schultzii, Bryol. Brit., p. 157, tab. 45. Rabenhor, Bryothec. Europ., No. 651. Trichostomum patens, var. piliferum, Muscol. Brit. p. 105.

Hab. Rocks near the Scalp, Co. Dublin, David Orr. Very fine on rocks by the side of Luggelaw, Wicklow. On the top of Fair Head, Antrim; and on several of the Connemara Mountains.

9. *G. patens* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 18, tab. 246. Bryol. Brit., p. 158, tab. 19. Trichostomum patens, Schwaegr. Suppl., tab. 37. Muscol. Brit., p. 105.

Hab. Moist rocks in subalpine parts of Ireland; on the top of Slemish, Antrim, 1806; wet rocks at the Waterfall, Powerscourt, bearing fruit in April; also on several of the mountains in Connemara; Galtee-more, Tipperary; Gougaunbarra, Cork, Isaac Carroll.

10. *G. ovata* (Web. et Mohr). It. Suec., tab. 2, f. 4. Muscol., Brit., Ed. 2, p. 71. Bryol. Europ., vol. III. Monogr., p. 21, tab. 254. Bryol. Brit., p. 160, tab. 13.

Hab. Mr. David Orr finds on rocks at Howth and Killiney a plant which the late Mr. Wilson considered to be this species, but it occurs only in a barren state at both localities, and cannot, therefore, be identified with certainty. Musheragh Mountain Cork, Isaac Carroll.

11. *G. leucophæa* (Greville). Scot. Crypt., Flor., tab. 284. Bryol. Brit., p. 161, tab. 30. Muscol. Brit., p. 70. Grimmia lævigata, Bridel., Bryol. Univ., 1, p. 773.

Hab. On trap rocks, near the Giant's Causeway, Antrim; also on a similar geological formation on the Island of Rathlin, 1837.

19. Schistidium. Br. et Schimp.

Capsule immersed in the perichætal leaves, roundish and wide mouthed. Operculum depressed rostellate, deciduous with the columella; annulus nearly wanting. Peristome single, of 16 lanceolate cribrose teeth, inserted below the mouth of the capsule, transversely barred without a medial line. Calyptra small, lacerated at the base. Inflorescence monoicous; male flowers gemmiform. Scarcely differing from Grimmia.

Diagnosis of Species.

Plants tufted; leaves hair pointed, blackish; teeth of peristome cribrose and lacerated; annulus none, ...	1. S. confertа.
Plants loosely cœspitose, leaves spreading from an erect base, ...	2. S. apocarpum.
Plants densely tufted, leaves crowded, rigid. Growing near the sea, . . .	3. S. maritimum.

1. *S. confertum* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 7, tab. 232. Bryol. Brit., p. 149, tab. 44. De. Notr., Briol. Ital., p. 711. Grimmia conferta (Funck). Schimp., Synops. Muscor., p. 199. G. apocarpa, var. conferta. C. Müller, Syn. Muscor.

Hab. On rotten trap rocks near Belfast. Only the variety β. incana, Grimmia pruinosa, Wils. M. S. has been collected, the typical form has not yet been observed in Ireland.

2 *S. apocarpum* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 7, tab. 233. Bryol. Brit., p. 150, tab. 13. De Notr., Briol. Ital., p. 711. Grimmia apocarpa, Turner, Muscol. Hib. p. 20. Smith, Engl. Bot., tab. 1134.

Hab. On stones, walls, and rocks. On trees at Killarney. This common moss varies much in appearance according to the localities where it grows. At Torc Cascade, Killarney, the var. δ. *stricta*, grows on rocks between the waterfall and the bridge, with rigid slender stems 3–4 inches long. I have collected the same variety near Brandon Head. I have not seen the variety mentioned by Taylor in Fl. Hib., which has the capsules higher than the perichætia.

3. *S. maritimum* (Br. et Sch.). Bryol. Europ. Monogr., p. 10, tab. 255. Bryol. Brit., p. 151, tab. 13. Grimmia maritima, Turner, Musc. Hib., tab. 3, f. 2. Muscol. Brit., p. 66.

Hab. Crevices of maritime rocks round the whole of Ireland. This truly maritime moss grows well in places where the spray of the sea dashes over it.

20. GLYPHOMITRIUM. Schwaegr.

Capsule pedicellate, erect, globular. Calyptra covering the entire mature capsule, campanulate, split at the base and furrowed. Peristome single, of 16 teeth, converging in pairs, reflexed when dry. Distinguished from Grimmia chiefly by the large plicate calyptra and geminate teeth.

1. *G. Daviesii* (Swaegr.). Suppl. 2, p. 41, tab. 113. Muscol. Brit., Ed. 2, p. 110. Bryol. Brit., p. 172, tab. 13. Grimmia Daviesii, Turner, Muscol. Hib., p. 24.

Hab. On rocks of different geological formations in the northern and western counties. On the basalt at Giant's Causeway; also at Fairhead, and Island of Rathlin, Antrim; near Brandon Head, Kerry. Very fine on rocks above Kylemore Castle, Galway. Near Bantry, Cork, Miss Hutchins; Glengariff and Killarney, Isaac Carroll. This pretty and very distinct Moss may be collected with its curious calyptræ in perfection about the 1st of May.

[2. *G. cylindraceum* (Taylor). Flor. Hib., p. 21.

Hab. Crevices of siliceous rocks on Blackwater-hill, Co. Kerry. I know nothing of this plant, save what is stated by the late Dr. Taylor, in the book quoted.]

21. PTYCHOMITRIUM. Br. et Schimp.

Capsule oval, erect and pedicellate. Calyptra campanulate, deeply furrowed, laciniate at the base. Peristome single, of 16 deeply bifid teeth, into two unequal filiform segments. Inflorescence monoicous. Plants growing in close tufts on walls and rocks, intermediate in appearance between species of Grimmia and some kinds of Orthotrichum.

6. *R. protensum* (Al. Braun). Bryol. Europ., vol. III. Monogr., p. 6, tab. 263. R. aquaticum, Bridel, Bryol., Univ. 1, p. 222. Bryol. Brit., p. 166, tab. 45. Briol. Ital., p. 676. Dicranum aciculare, γ. *gracile*, Turn. Musc. Hib., p. 67.

Hab. Rocky beds of rivulets, and on wet rocks, on the highest mountains. Upper Lough Bray, Wicklow, D. Orr; and on some of the Wicklow Mountains; Brandon, and Macgillicuddy's Recks, Kerry; Mountain streams near Kylemore, Connemara. Rather rare in Ireland.

7. *R. ellipticum* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 5, tab. 261. Bryol. Brit., p. 164, tab. 19. Dicranum ellipticum, Turner. Muscol. Hib., p. 76. Trichostomum ellipticum, Muscol. Brit., Ed. 2, p. 109.

Hab. Moist rocks on high mountains. Fair Head, Antrim; Brandon, Kerry; Lugnaquillia, Wicklow; Maam-torc, Galway; near Bantry, Miss Hutchins; Giant's Stairs, Monkstown, Cork, Isaac Carroll. Rare in Ireland.

8. *R. fasciculare* (Bridel). Bryol. Univ. 1, p. 218. Br. et Schimp. Bryol. Europ., vol. III., tab. 1. Wilson, Bryol. Brit., p. 167, tab. 19. De Notr., Briol. Ital., p. 675. Trichostomum fasciculare, Turner. Musc. Hib., p. 39. Engl. Bot., tab. 2005. Hook. and Tayl., Muscol. Brit., p. 108.

Hab. On rocks and stones among the mountains and in upland parts of the country. Frequent throughout Ireland.

Tribe 4. Leucobryeæ.

23. Leucobryum. Hampe.

Calyptra cuculliform, pale, slightly inflated when young. Capsule oblong, cernuous, slightly strumose, pedicellate. Peristome of 16 bifid teeth, as in Dicranum; annulus none. Lamina of the leaves composed of three strata of cells, the superficial larger, hyaline and fenestrated, the middle larger, denser, and green. The whole plant of a pale white glaucous colour. Inflorescence monoicous.

1. *L. glaucum* (Hampe). Rabenhor., Bryothec. Europ., No. 30. Bryol. Brit., p. 82, tab. 16. Briol. Ital., p. 285. Dicranum glaucum (Hedw.). Turner, Musc. Hib., p. 73. Eng. Bot., tab. 2166, Hook. and Tayl., Muscol. Brit., Ed. 2, p. 92. Oncophorus glaucus, Bryol. Europ., vol. I., Monogr., p. 5, tab. 97 et 98.

Hab. Frequent on heaths and bogs, also sides of glens in many parts of the country. Shady woods about Killarney, and sometimes at considerable elevations on the mountains, but rarely met with in fruit. Near Bantry, fruiting, Miss Hutchins.

Tribe 5. TRICHOSTOMACEÆ.

Sect. 1. *Phasceæ.* Capsule without operculum.

24. PHASCUM. Linn.

Calyptra variable, small, conical, or campanulate, cuculliform. Capsule spheroid, more or less attenuated at the apex or conoid. Leaves membranaceous, ovate, or oblong, the nerve sometimes excurrent; areolation loose, the lower cellules more elongated, larger, and variously chlorophyllose. Mostly annual plants, growing gregariously on the ground.

Diagnosis of Species.

Capsule immersed in the leaves, . . .	1. P. CUSPIDATUM.
Capsule exerted, widely elliptic, apex oblique; calyptra cucullate. Monoicous, . .	2. P. BRYOIDES.
Capsule round ellipsoid, apex short. Synoicous, ...	3. P. RECTUM.
Capsule on curved pedicel, nutant. Synoicous, ...	4. P. CURVICOLLUM.

1. P. *cuspidatum* (Schreber). De Phasc., p. 8, tab. 1, f. 2. Bryol. Brit., p. 31, tab. 5. Bryol. Europ., vol. I., tab. 4. Muscol. Brit., p. 8. Rabenhor., Bryothec. Europ., No. 304. Turner, Muscol. Hib., p. 3. P. acaulon, Linn. Sp. Plant, 1570.

Hab. Banks and fields. Frequent in the county of Dublin, bearing fruit in February. The variety δ. *piliferum* Bryol. Brit., occurs on hedge banks near Baldoyle and at Howth.

2. *P. bryoides* (Dicks.). Crypt., Fasc. 4, tab. 10, f. 3. Engl. Bot., tab. 1180. Bryol. Brit., p. 33, tab. 5. Bryol. Europ., vol. I., tab. 5. Briol. Ital., p. 734. Rabenhor., Bryothec. Europ., No. 303.

Hab. Banks and fields. Howth, D. Orr. This species is very rare in Ireland, the locality indicated being the only one where it has hitherto been found, and even there very sparingly.

3. *P. rectum* (Wither.). Bot. Arr., Ed. 4, p. 771, tab. 18, f. 1. Smith Fl. Brit. 3, p. 1153. Turner, Muscol. Hib., p. 4. Bryol. Brit., p. 31, tab. 5. Schimp., Synops. Musc., p. 20. Bryella recta, Berk., Handb. Brit. Mosses, p. 300.

Hab. Banks and hedges. Frequent in the south of Ireland, Tayl. in Fl. Hib. Rarer elsewhere through the country, though frequent in Co. Dublin.

4. *P. curvicollum* (Hedw.). Sp. Muscor., p. 21. Weber. et Mohr, Bot. Tasch., p. 65, tab. 6. Engl. Bot., tab. 905. Muscol. Brit., p. 11. Bryol. Brit., p. 31, tab. 5. Rabenhor., Bryothec. Europ., No. 154.

Hab. Banks and fields. Near Dublin. Taylor, in Flor. Hib. I have never collected this plant in Ireland, nor seen Irish specimens of it.

25. SYSTEGIUM. Schimp.

Capsule wanting operculum, but with traces of a deciduous lid.

S. crispum (Schimp.). Synops. Muscor., p. 30. Phascum crispum. (Hedw.). Turner Musc. Hib., p. 2. Bryol. Brit., p. 37, tab. 5. Rabenhor., Bryothec. Europ., No. 30. Astomum crispum, Bryol. Europ., vol. I. Monogr., p. 2, tab. 12.

Hab. Banks and fields. Near Belfast, Templeton. This species appears to be extremely rare in Ireland.

Sec. 2. *Weissieæ.* *Capsule without peristome.

26. GYMNOSTOMUM. Hedwig.

Diagnosis of Species.

a. Inflorescence dioicous.

Capsule elliptic-oblong, narrow at the mouth; lid not rostrate, ...	1. G. TENUE.
Capsule erect, oval; lid shortly rostrate, .	2. G. RUPESTRE.
Capsule broadly ovate; lid rostrate and adherent to the columella, . . .	3. G. CURVIROSTRUM.

aa. Inflorescence monoicous.

Capsule contracted at the mouth, elliptical, exerted; lid rostrate, ...	4. G. MICROSTOMUM.
Capsule hardly contracted at the mouth; sporangium not adherent to the columella,	5. G. TORTILE.

1. *G. tenue* (Schrad.). Coll. Plant. Crypt., No. 31. Hedw., Sp. Musc.,

p. 37, tab. 4. Bridel, Bryol. Univ. 1, p. 64. Muscol. Brit., p. 24. Bryol. Brit., p. 41. tab. 7. Rabenhor., Bryothec. Europ., Nos. 61 et 405.

Hab. On rocks of sandstone formation. Brandon, Co. Kerry, Taylor, in Fl. Hib.

2. *G. rupestre* (Schwaegr.). Suppl., vol. I., p. 11, tab. 33-34. Nees et Hornsch., Fl. Germ. 1, p. 155, tab. 10, f. 16. Muscol. Brit., p. 19. Bryol. Brit., p. 42, tab. 32.

Hab. Fissures of wet rocks in subalpine rivulets. Dargle river, Wicklow, Taylor. Glens in Antrim, not rare. I have not met with it in other parts of Ireland.

3. *G. curvirostrum* (Hedw.). Stirp. Crypt., tab. 34. Engl. Bot., tab. 2214. Muscol. Brit., p. 19. Bryol. Brit., p. 42, tab. 6. Bryol. Europ., vol. I. tab. 35. Rabenhor., Bryothec. Europ., No. 60.

Hab. Rocks, &c., in subalpine parts of the country. Fair Head, Antrim, Templeton. Mangerton, Kerry—Taylor. Glen at Cushendall, Antrim. This moss is rare in Ireland.

4. *G. microstomum* (Hedw.). Stirp. Crypt., 3, p. 71, tab. 30. Engl. Bot., tab. 2215. Muscol. Brit., p. 25, Bryol. Brit., p. 44, tab. 7. Rabenhor., Bryothec. Europ., No. 307. Hymenostomum, Bryol. Europ., vol. I. Monogr., p. 4, tab. 16.

Hab. Banks and fields. Common in many parts of Ireland, especially the northern counties. The varieties β. γ. and δ. of Wilson are all occasionally found in Ireland.

5. *G. tortile* (Schwaegr.). Suppl. 1, 29, tab. 10. Bryol. Brit., p. 45, tab. 38. Rabenhor., Bryothec. Europ., No. 408. Hymenostomum tortile. Bryol. Europ., vol. I. Monogr., p. 6, tab. 18–19. Briol. Ital., p. 606.

Hab. Limestone rocks at Castle Taylor, Galway. The only Irish specimens of this moss were collected very sparingly at this habitat. The plant so named by Dr. Taylor in Fl. Hib. is Trichostomum crispulum, (Bruch et Muller).

6. *G. calcareum* (Nees et Hornsch.). Bryol. Germ. 1, p. 153, tab. 10, f. 15. Rabenhor., Bryothec. Europ., Nos. 62 et 351.

Hab. The plant which is supposed to be this species grows on old walls at Lota, near Middleton, Cork, but is always barren. It covers the walls where it grows so closely as to resemble green plush. Isaac Carroll, *in litt.*

27. Pottia. Ehrh.

Calyptra cuculliform, smooth or rough on the apex. Capsule either exerted or immersed, obovate-truncate or oval oblong. Peristome none. Leaves mostly entire, ovate-oblong or spathulate; nerve frequently excurrent into a mucro; areolation loose or dense, the cellules often of a rectangular or quadrate form, enlarged at the base. Small annual or biennial mosses growing chiefly on the ground.

With this genus, Mr. Mitten unites that of Anacalypta, of Röhling, and in "Journal of Botany," vol. ix., for January, 1871, arranges the species in the following manner:—

Diagnosis of Species.

a Leaves with accessory lamellæ on the nerve, ... 1. P. cavifolia.

aa Leaves without accessory lamellæ.

b Calyptra scabrous.

Leaves obtuse, ... 2. P. Wilsoni.

Leaves acute, ... 3. P. Starkeana.

bb Calyptra smooth.

c Leaves serrulate towards the apex.

Nerve not excurrent, ... 4. P. Heimii.

Nerve excurrent, ... 5. P. lanceolata.

cc Leaves in 5 rows, smooth.

Capsule turbinate, ... 6. P. truncata.

ccc Leaves in 8 rows, rough.

Nerve excurrent into a long point, . . 7. P. crinita.

1. *P. cavifolia* (Ehrh.). Beiträge —Bryol. Europ., vol. ii., Monogr., p. 7, tab. 118. Rabenhor., Bryothec. Europ., No. 724. Gymnostomum ovatum (Hedw.). Engl. Bot., tab. 1889. Turner, Muscol. Hib., p. 9. Muscol. Brit., p. 21. Bryol. Brit., p. 92, tab. 7. Barbula cavifolia, Schimp. Synop. Muscor., p. 734.

Hab. On the tops of walls built of mud, and by way sides. Very common in the neighbourhood of Dublin. Near Cork, Tayl. in Fl. Hib.

2. *P. Wilsoni* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 11, tab. 122. Gymnostomum Wilsoni. Hooker, in Bot. Miscel. 1830, vol. I., p. 43, tab. 41. Suppl. Eng. Bot., tab. 2710. Rabenhor., Bryothec. Europ., No. 806.

Hab. Banks and tops of walls built of mud, especially near the sea. Howth, Killiney, and Bray Head. This plant, which has been recognised as Irish only within the last few years, may not be rare in similar places on the coast. Great and Little Islands, Cork, Isaac Carroll.

3. *P. Starkeana* (C. Müller). Synops. Musc. Mitten, in "Journal of Botany," vol. IX., No. 97. Nees et Hornsch. Bryol. Germ., tab. 36, f. 2. Bryol. Brit., p. 98, tab. 14. Briol. Ital., p. 582. Rabenhor., Bryothec. Europ., No. 831. Weissia Starkeana, Muscol. Brit., p. 79, tab. 14. Grimmia Starkeana, Turner, Musc. Hib., p. 26. Gymnostomum conicum, Schwaegr. Suppl., tab. 9.

Hab. Banks and fields. Howth, Killiney, and near Clontarf, Co. Dublin. Near Cork, Taylor. Near Youghal, Isaac Carroll.

The variety *β. brachyodus*, Weissia affinis, Hook and Tayl., grows on the railway banks near the Killiney Station, Bray Railway. Pottia minutula (Br. et Schimp.), is now considered a form of this moss, there being intermediate states connecting the normal form, which has a peristome of 16 teeth, through the variety *β.* which has the teeth of peristome very short or without them, to the gymnostomous form of Pottia minuluta var. *γ conica.*

4. *P. Heimii* (Br. et Schimp.). Bryol. Europ. vol. II. Monogr., p. 12, tab. 124. Bryol Brit., p. 96, tab. 7. Rabenhor., Bryothec. Europ., No. 401. Gymnostomum Heimii (Hedw.), Turner, Musc. Hib., p. 9. Muscol. Brit., p. 22.

Hab. Banks and marshes near the sea. Marshy meadows near the North Wall, and Portmarnock, Dublin. Westport, Mayo. Rare in the north ; frequent in the southern counties, Tayl. in Fl. Hib.

5. *P. lanceolata* (Müller). Synops. Muscor.—Mitten in Seemann's "Journal of Botany," vol. IX., p. 3. Anacalypta lanceolata, Röhling. Moosgeschichte Deutschl. Nees et Hornsch., Bryol. Germ., tab. 36, fig. 3. Bryol. Brit., p. 97, tab. 14. Rabenhor., Bryothec. Europ., No. 252. Gymnostomum intermedium, Turner, Musc. Hib., p. 7, tab. 1, fig. *a. c.* Weissia lanceolata, Muscol. Brit., Ed. 2, p. 80.

Hab. Fields, banks, and waste ground where the soil is of a calcareous nature. Frequent in many parts through the county of Dublin. It is one of the mosses which makes its appearance

annually among the plants in the Glasnevin Botanic Garden, but I have not met with it in the north or west of Ireland. In its normal form the peristome is furnished with 16 teeth, in which state it always occurs near Dublin. Mr. Mitten, however, states that the peristome in this respect is very variable, some forms being gymnostomous.

6. *P. truncata* (Br. et Schimp.). Bryol. Europ., vol. II., Monogr., p. 9, tab. 120–121. Bryol. Brit., p. 94, tab. 7. Gymnostomum truncatum, Nees et Hornsch. Bryol. Germ., tab. 9, f. 8. Muscol. Brit., Ed. 2, p. 22, tab. 7.

Hab. Fallow fields, banks and moist grounds all through Ireland. This common moss varies much in its forms, and in the length of the capsule, compared to its breadth, as well as in the lid. The variety *β. major*—Gymnostomum intermedium, of Turner, Musc. Hib., tab. 1, fig. *a*, is supposed by Mitten to be the gymnostomous state of P. lanceolata. Dr. Taylor mentions in Fl. Hib. a form which is found near Cove, Cork, with capsules quite cylindrical.

7. *P. crinita* (Wilson). Bryol. Europ., vol. II. Suppl. 1, tab. 123, Bryol. Brit., p. 95, tab. 41. C. Müll. Synops. 2, Suppl., p. 622. De Notr., Briol. Ital., p 586. Rabenhor., Bryothec. Europ., No. 805.

Hab. Banks facing the sea at Howth, where it was first collected by D. Orr. Carrigloe and rocks west of Cork Harbour, Isaac Carroll. The specimens so named by Mr. Wilson differ only slightly in areolation from those named by same author, P. Wilsoni. The long piliferous pointed leaves and smooth calyptra appear to be the principal marks of distinction between them.

28. ANŒCTANGIUM. Br. et Schimp.

Calyptra small cucullate. Fruit pleurocarpous; vaginula perfect, cylindrical. Capsule pedicellate, erect or partially inclined, ovate or obovate, slightly inflated at the neck. Peristome none, annulus narrow, falling away in pieces; lid slender, rostrate. Leaves linear-lanceolate, or subulate; areolation small and round in upper part of leaf, basal cellules larger, elongated, and diaphanous. Inflorescence dioicous.—The pleurocarpous fruit and perfectly formed perichætum render this genus somewhat paradoxical as to the position it should take in artificial arrangements or even natural arrangements. Eminent authors have held different views concerning it. In placing it here, Mr. Mitten is followed.

1. *A. compactum* (Schwaegr.). Suppl., tab 2, Bryol. Brit., p. 311, tab. 6. Funck. Deutsch. Moose, tab. 5, f. 5. Rabenhor., Bryothec. Europ., No. 123. Bryol. Europ., vol. I. Monogr., p. 5, tab. 37. Gymnostomum æstivum, Hedw. Sp. Musc., tab. 2, f. 4. G. luteolum, Engl. Bot., tab. 220. Hedwigia æstiva, Muscol. Brit., p. 18.

Hab. In the crevices of damp subalpine rocks. Near Bantry, Miss Hutchins, Fl. Hib. Near a small lake on Galtee-more, Co. Tipperary. Rare in Ireland.

Sect. 3. *Euweissieæ.* Peristome of 16 teeth.

29. WEISSIA. Hedw.

Calyptra cuculliform or cleft at the side. Capsule ovate, annulate, pedicellate. Peristome single, of 16 entire or perforated teeth, without a medial line; lid with beak inclined. Leaves costate; areolation rather dense. Inflorescence monoicous or dioicous. Intermediate between Gymnostomum and Didymodon.

Diagnosis of Species.

Leaves channelled, linear-lanceolate, acute, incurved or crisped when dry, . . 1. W. VIRIDULA.

Leaves subflexuose, much crisped when dry, 2. W. CIRRHATA.

Stems elongated, leaves narrow, rigid and crisped when dry, ... 3. W. VERTICILLATA.

1. *W. viridula* (Bridel). Bryol. Europ., vol. I., Monogr., p. 5, tab. 21. Schimp., Synop. Muscor., p. 50. Rabenhor., Bryothec. Europ., No. 169. W. controversa (Hedw.). Hook. and Taylor, Muscol. Brit., p. 85. Bryol. Brit., p. 46, tab. 15.

Hab. Dry banks and waste places throughout Ireland. This very common moss varies considerably in size and length of pedicel. At Howth on banks facing the sea a rather remarkable form is found, with capsules more cylindrical and with taller stems than in the typical form.

2. *W. cirrhata* (Hedw.). Sp. Musc., tab. 12. Bryol. Europ., vol. I, Monogr., p. 9, tab. 25. Bryol. Brit., p. 47, tab. 15. Rabenhor., Bryothec. Europ., No. 106.

Hab. On rocks in mountainous districts. Very fine on Sugar-loaf Mountain, county of Wicklow, on the side facing Bray. Fruiting in March. Howth, D. Orr. Mountains in the South of Ireland, Dr. Taylor. The nearly allied species, Weissia crispula, of Hedw., is still a desideratum to Ireland. The plant published in Fl. Cork, under that name, is not the right one, as I am informed by Mr. Carroll.

3. *W. verticillata* (Bridel). Spec. Musc., p. 121. Nees et Hornsch., Bryol. Germ., tab. 32. Muscol. Brit., p. 86. Bryol. Brit., p. 49, tab. 15. Grimmia verticillata, Turner, Musc. Hib., p. 31. Eucladium verticillatum, Bryol. Europ., vol. I., Monogr., p. 3, tab. 40. Schimp. Synops. Muscor., p. 135. Rabenhor., Bryothec. Europ., No. 1157.

Hab. Chiefly on calcareous wet rocks and banks, especially near the sea, where it is frequently so incrusted with a calcareous deposit as to be nearly as hard as the rock on which it grows. On schistose rocks at Cromagloun it may be seen free from any deposit of calcareous matter. Although a common species, it is rarely found in a fruiting state in Ireland.

Sect. 4. *Trichostomeæ.* Peristome of 16 or 32 teeth, approached in pairs.

[30. Splachnobryum. C. Müller, Verhandl. z. B. Wien. 1869, p. 501.

S. Wrightii (C. Müll.). Braithwaite, in "Journal of Botany," for July, 1872, Plate 123, and our Plate 24. Entosthodon minimus, Hunt, in "Manchester Lit. and Phil. Society's Memoirs," XI., p. 19, 1871. Amblyphyllum hibernicum, Lindberg, M.S.

"Dioicous, minute, gregarious; stems one-third to a quarter of an inch high, simple subflexuose, dark brown. Leaves light green, distant with a narrow and slightly recurved base, patent, flattish, obovate or spathulate, rounded at apex, entire or minutely serrulate in the male; crenulate in the upper part of the female plant, nerve thick and prominent at back, vanishing below apex, cells lax, large, pellucid, smooth, rhombo-rectangular at base, rhomboidal above, smaller and nearly circular at margin. Male flower terminal autheridia without paraphyses. Capsule erect, obconical at base, subcylindric, wide-mouthed; operculum conical acute; teeth of peristome very slender, pale red, erect; calyptra long, conical, narrow" (Braithwaite).

Hab. On the walls and floors of a forcing plant pit, Botanic Garden, Glasnevin, D. Orr. This little moss has for several years been noticed growing annually within this limited locality. Although the male plants occur in great abundance, the female are scarce, and neither are found elsewhere in the garden. It is no doubt an alien which has been introduced with foreign plants from the West Indies, and become naturalised here where it grows.]

31. DIDYMODON. Br. et Schimp.

Calyptra cleft at the side. Capsule oblong or subcylindrical, annulate, pedicellate. Peristome single, of 16 teeth, which are entire or slightly bifid, very shortly joined at the base, but mostly free, and approaching in pairs, sometimes appearing as 32, fugacious. Leaves with dot-like areolation, and frequently opaque with chlorophyll, basal cellules longer and narrower, more pellucid.

So little difference exists between this genus and Trichostomum, that the species described under it by authors have been referred to the latter by Mitten, Lindberg, and some others. De Notaris has however retained it in his great work on the mosses of Italy, "Epilogo della Briologia Italiana," 1869; and as the genus Didymodon is so familiar to British Bryologists, it has been thought better to let it remain on our list.

Diagnosis of Species.

A. Inflorescence dioicous.

Leaves long, broadly subulate, spreading; margin slightly undulated; crisped when dry, ...	1. D. CYLINDRICUS.
Leaves oblong, ligulate, apiculate, flexuose and crisped when dry, ...	2. D. FLEXIFOLIUS.
Leaves subsquarrose, recurved and serrated at margin; crisped when dry, ...	3. D. RECURVIFOLIUS.
Leaves acutely ovate; margin revolute, nerve reaching the apex; areolation dot-like,	4. D. LURIDUS.

B. Inflorescence monoicous.

Leaves spreading and recurved, oblong-lanceolate, ...	5. D. RUBELLUS.

1. *D. cylindricus* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 5, tab. 187. Schimp., Synops. Muscor., p 132. Bryol. Brit., p. 108, tab. 33. Trichostomum tenuirostre, Lindberg, Trichost. Europ., p. 15. Weissia tenuirostris, Muscol. Brit., p. 83, tab. 3.

Hab. On wet banks and rocks near waterfalls, &c. At the Waterfall, Powerscourt, Wicklow; also by streams among the Dublin Mountains. Very frequent about Killarney; Connemara; Benbulben, Sligo; in "The Glens," Co. Antrim, &c.

2. *D. flexifolius* (Hook. et Tayl.). Muscol. Brit., Ed. 2, p. 115, tab. 20. Bryol. Brit., p. 109, tab. 20. Rabenhor., Bryothec. Europ., No. 662. Leptodontium flexifolium, Hampe in Linnæa, 20, p. 70. Trichostomum flexifolium, Engl. Bot., tab. 2493.

Hab. On mossy ground in rather elevated situations. A plant agreeing with this very closely, has been gathered in the County of Antrim, near Cushendall; and in County Dublin, near Killiney. In both instances the fruit is very young, but the remarkable leaves, unlike those of any other species of the genus, can hardly be mistaken. This is all that is known of the plant having occurred in Ireland.

3. *D. recurvifolius* (Tayl.). Bryol. Brit., p. 110, tab. 41. Leptodontium recurvifolium, Lindberg, Trichost. Europ., p. 17.

Hab. On Knockavohila, a mountain between Kenmare and Killarney, Ireland, Dr. Taylor. Not hitherto we believe found elsewhere, or by any other person in the British Isles. Lindberg points out the affinities of this moss to the foreign genus Holomitrium of Bridel.

4. *D. luridus* (Hornsch.). Bryol. Europ., vol. II. Monogr. 4, tab. 186. Schimp., Synop. Musc., p. 131. Bryol. Brit., p. 107, tab. 41. Briol. Ital., p. 576. Rabenhor., Bryothec. Europ., No. 661. Bryum obtusifolium, Turner, Musc. Hib. (in part).

Hab. On walls and rocks chiefly of limestone. Abundant on walls between Cork and Passage near the sea, W. Wilson, 1829; also found in the same place by Isaac Carroll, who pointed it out to me there. On a wall near Castle Gregory, and near Tralee, Co. Kerry.

5. *D. rubellus* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 3, tab. 185. Schimp., Synop. Musc., p. 130. Bryol. Brit., p. 106, tab. 17. Briol. Ital., p. 564. Weissia curvirostra, Hook. and Tayl., Muscol. Brit., p. 84.

Hab. Wet banks and damp walls. Also among heath and on sands near the sea, frequent in many parts of Ireland.

32. Trichostomum. Br. et Schimp.

Calyptra cucullate or campanulate. Capsule ovate-oblong or roundish, straight or curved. Peristome of 32 filiform, more or less perfect teeth, disposed in pairs, often joined at base by a short membrane so as to appear 16. Leaves costate, varying from lanceolate-subulate, or ovate to spathulate; areolation dense and dot like above, more lax at the base.

Diagnosis of Species.

A. Inflorescence dioicous.

Capsule exannulate, erect; leaves adpressed at base, oblong, mucronulate, . .	1. T. FLAVOVIRENS.
Capsule annulate, ovate; leaves, with the margins of upper half incurved, cucullate, at apex mucronate, ...	2. S. CRISPUM.
Capsule annulate; leaves mucronate, not cucullate at apex, ...	3. T. MUTABILE.

B. Inflorescence monoicous.

Leaves softish, lanceolate, rather obtuse; nerve disappearing near the apex, .	4. T. TOPHACEUM.

1. *T. flavovirens* (Bruch.) in Müll. Musc. Sardin. Bryol. Europ., vol. II. Monogr., p. 6, tab. 172. Mitten in Seemann's "Journal of Botany," vol. VI., 1868, p. 97, tab. 77, f. 1. Briol. Ital., p. 502.

Hab. Sand hills at Portmarnock and between Malahide and Portrane in great abundance, but always barren. It also grows on banks facing the sea at Howth; Arklow, Wicklow.

2. *T. crispulum* (Bruch et Schimp.). Bryol. Europ., vol. II. Monogr., p. 7, tab. 173. Bryol. Brit., p. 111, tab. 41. Briol. Ital., p. 503. Rabenhor., Bryothec. Europ., No. 532. Didymodon crispulus, Tayl. in Fl. Hib., p. 18.

Hab. Rocks and banks on limestone formations chiefly, but also on slate, basalt, &c., in many parts of Ireland. At Muckross, in fruit, June, 1864; Dunkerron, Kerry; Benbulben, Sligo.

3. *T. mutabile* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 8, tab. 171. Bryol. Brit., p. 112, tab. 41. Briol. Ital., p. 304. Rabenhor., Bryothec. Europ., No. 559. Didymodon brachydontius, Tayl. in Fl. Hib., p. 18. Gymnostomum tortile, ibid., p. 10.

Hab. Rocks and moist banks. Very frequent in the southern counties. It also occurs in considerable abundance on the basaltic rocks of Antrim, but generally barren. Fruiting near Kenmare, Co. Kerry.

4. *T. tophaceum* (Br. et Schimp.). Bryol. Europ., vol. II. Monogr., p. 9, tab. 175. Bryol. Brit., p. 113, tab. 20. Lindberg, Trichost. Europ., No. 10, p. 17. Rabenhor., Bryothec. Europ., No. 558. Didymodon trifarium, Hook. and Tayl., Muscol. Brit., Ed. 2, p. 118, tab. 20.

Hab. On wet clay banks and on rocks. Frequent in Counties of Dublin and Wicklow; Connemara, Galway; in "The Glens," Antrim; Cork, Isaac Carroll; and many other parts of Ireland.

33. DITRICHUM. Timm.

Calyptra elongate. Capsule pedicellate, ovate or oblong, erect. Peristome similar to that of Trichostomum, teeth filiform, approximated in twos or threes. Leaves mostly subulate from a rather broad base, which is partially amplexicaul, secund or falcate, shining with a silky lustre when dry. Small mosses differing from Trichostomum more in appearance than in any real characters.

Diagnosis of Species.

Inflorescence dioicous.

Stems loosely cæspitose; leaves spreading or secund, lanceolate-subulate; nerve excurent, ...	1. D. PUSILLUM.
Stems short, not matted; leaves spreading, subulate, setaceous; nerve broad, excurrent, ...	2. D. HOMOMALLUM.
Stems elongated, densely cæspitose, and flexuose; leaves secund at apex of shoots, ...	3. D. FLEXICAULE.

1. *D. pusillum* (Timm.) Prodromus. Flor. Megapolitana, p. 216. Trichostomum pusillum, Hedw. Stirp. 1, p. 74, tab. 28. Engl. Bot., tab. 2380. T. tortile, Bryol. Brit., p. 115, tab. 43. Leptotrichum tortile. Hamp. in Linnæa, 1847. Schimp., Synops. Muscor., p. 143. Briol. Ital., p. 516. Rabenhor., Bryothec. Europ., No. 424.

Hab. Sandy banks, quarries, &c. Near Belfast, Drummond. In the late Mr. Templeton's Garden, Cranmore, Belfast, 1837, Dodge's-glen, Cork, D. Murray and Isaac Carroll. Rare in Ireland.

2. *D. homomallum* (Hampe), Linnæa, 1847. Leptotrichum homomallum, Müller, Synop. Musc., p. 1453. Schimp. Synop. Muscor., p 143. Rabenhor., Bryothec. Europ., No. 663. Trichostomum homomallum, Bryol. Europ., vol. II. Monogr., p. 16, tab. 181. Bryol. Brit., p. 116, tab. 20. Didymodon heteromallum, Muscol. Brit., Ed. 2, p. 119.

Hab. Among heath and on sandy and clay banks. Frequent in the hilly counties of Ireland, and all round the coasts, but rather rare in the central counties.

4. *D. flexicaule* (Hampe), l. c. Leptotrichum flexicaule, Müller, Synop. Muscor. 1, p. 449. Schimp., Synop. Muscor., p. 144. Rabenhor., Bryothec., Europ., No. 423. Trichostomum flexicaule, Bryol. Europ., vol. II. Monogr., p. 15, tab. 180. Bryol. Brit., p. 116, tab. 42.

Hab. On sand-hills near the sea, and on dry rocky places inland. Abundant at Portmarnock and Malahide, Dublin; Arklow, Wicklow; Killala, Mayo; Benbulben, Sligo, and many other parts of Ireland, but always barren.

Sect. 5. *Tortulæ.* Peristome of 32 teeth, mostly long and more or less contorted from left to right.

34. TORTULA (et BARBULA.) Hedw.

Calyptra often elongated, cleft at side, or cuculliform. Capsule ovate-oblong, or subcylindrical, long pedicellate. Peristome single of 16–32 filiform, more or less contorted teeth, united at base into a short or long membranous tube; rarely without teeth. Leaves very various in form, with nerves short or long; sometimes excurrent into a mucro, or piliferous; areolation dense in upper part of leaf; basal cellules larger and diaphanous. Nearly allied to Trichostomum; differing principally in the torsion of the teeth.

Diagnosis of Species.

a. Leaves with accessary lamellæ on nerve, 1. T. LAMELLATA.

aa. Leaves with filamentous excrescences on the upper side of nerve.

Leaves with margins incurved to their points; calyptra small, covering half the capsule, ...	2. T. RIGIDA.
Calyptra small, covering little more than the lid, ...	3. T. AMBIGUA.

Leaves with a short blunt mucro, . .	4. T. ALOIDES.

aaa. Leaves with nerve naked, and margins revolute.

Leaves oval-oblong, apiculate, nerve strong,	5. T. ATROVIRENS.
Leaves oblong, lanceolate, ...	6. T. REVOLUTA.
Leaves ovate and acuminate, . . .	7. T. HORNSCHUCHIANA.

b. Leaves with margins plane.

Leaves oblong, lanceolate, obtuse, . .	8. T. CONVOLUTA.
Leaves broadly ovate, acuminate, . .	9. T. CUNEIFOLIA.
Leaves rather flaccid, mucronate, . . .	10. T. VAHLEANA.
Leaves oblong, obtuse, with long hair points,	11. T. MURALIS.

bb. Leaves with margins slightly recurved.

Leaves apiculate or mucronate, . . .	12. T. UNGUICULATA.
Leaves lanceolate, nerve subexcurrent; capsule without annulus, ...	13. T. FALLAX.
Capsule with annulus, ...	14. T. VINEALIS.
Leaves patent, imbricated, canaliculate, .	15. T. SPADICEA.
Leaves spreading, recurved, lanceolate, carinate, ...	16. T. RIGIDULA.
Leaves long, narrow, incurved, or uncinate,	17. T. INSULANA.
Leaves tristichous, much recurved, . .	18. T. REFLEXA.

c. Leaves large, oblong, or spathulate.

Leaves subspathulate, nerve excurrent, .	19. T. SUBULATA.
Leaves large, obtuse, emarginate, .	20. T. LATIFOLIA.
Leaves with nerve excurrent into a long smooth hair-like point, . . .	21. T. LÆVIPILA.
Leaves with nerve excurrent in a long rough hair-like point, . . .	22. T. RURALIS.
Leaves oblong, spathulate, carinate, with long rough hair-like point, ...	23. T. INTERMEDIA.
Leaves with thick, spongy, gemmiparous nerve, ...	24. T. PAPILLOSA.
Leaves nerve excurrent into a short rough point, ...	25. T. PRINCEPS.

cc. Leaves tortuose and cirrhate.

Leaves with margins much undulated, .	26. T TORTUOSA.

Leaves long, loosely inserted, cirrhate when dry, ... 27. T. HIBERNICA.

Leaves with margins sinuous on upper half, 28. T. SINUOSA.

Leaves linear, very fragile, and easily broken off, ... 29. T. FRAGILIS.

Leaves squarrose, and slightly undulated, . 30. T. SQUARROSA.

1. *T. lamellata* (Lindberg). Om. de. Europeiska Trichostomeæ, p. 23. Helsingfors, 1864. Schimper, Synopsis, p. 122. Rabenhor., Bryothec. Europ., No. 819. Gymnostomum ovatum, *var. δ. gracilis*, Wils., Bryol. Brit., p. 93. G. ovatum, *var. β., gracilis*, Hook. and Tayl., Muscol. Brit., Ed. 2, p. 2.

Hab. On the tops of mud walls, &c. Abundant in many places near Dublin, but not of general occurrence elsewhere in Ireland. This rather singular moss, which forms an intermediate link between the genera Pottia and Tortula, has quite the aspect, when growing, of other species of the latter genus, and very unlike the normal state of Pottia ovata, of which it has so long been considered a variety. It is, however, always gymnostomous in this country. In a young state the appearance of teeth may sometimes be seen through the lid of the capsule.

2. *T. rigida* (Schultz). Recens. Gen. Barbula, et Syntrichia, tab. 32, f. 1. Bryol. Brit., p. 120, tab. 32. Rabenhor., Bryothec. Europ., No. 235. Briol. Ital., p. 529. Barbula rigida, Bryol. Europ., vol. II. Monogr., p. 13, tab. 137. Schimp., Synops. Muscor., p. 36.

Hab. On the tops of walls. Near Chapelizod, Cardiff's Bridge, on Royal Canal, and other places near Dublin; also near Cork; but rare elsewhere in Ireland.

3. *T. ambigua.* (Wils.). Bryol. Brit., p. 120, tab. 42. T. rigida. Turner, Musc. Hib. Spicil., p. 43. Fl. Hib., p. 25. Bryol. Europ. Monogr., p. 14, tab. 2. Lindberg, Europ. Trichost., p. 25. Barbula ambigua, Rabenhor., Bryothec. Europ., No. 226.

Hab. On the tops of walls. Abundant near Dublin and Cork. In Fl. Hib. T. rigida, and following species are confounded with this one.

4. *T. aloides* (Koch.) De Notr., Musc. Ital., 1, p. 15, tab. 1. Briol. Ital., p. 528. Bryol. Brit., p. 121, tab. 42. Barbula aloides, Bryol. Europ., vol. II. Monogr., p. 15, tab. 139. Lindberg, Europ. Trichost., p. 26. Rabenhor., Bryothec. Europ., No. 786.

Hab. Clay banks and fields chiefly; but also on walls. This is the most generally distributed of all the thick-nerved species in Ireland. I have collected it in Mayo, Sligo, and Galway, and in the southern and eastern counties; but it is not common in the north.

5. *T. atrovirens* (Taylor), in "London Journal of Botany," Jan., 1846, vol. v. Grimmia atrovirens, Smith, Engl. Bot., tab. 2015. Didymodon nervosus, Hook. and Tayl., Muscol. Brit., Ed. 2, p. 115. Desmatodon nervosus, Bryol. Europ., vol. II. Monogr., p. 6, tab. 132. Rabenhor., Bryothec. Europ., No. 830. Bryol. Brit., p. 103, ab. 20.

Hab. On banks generally near the sea. At Killiney, Dr. Taylor in Fl. Hib. Abundant at Howth. On Bray Head, Wicklow; Youghal, Cork; E. Sargint. Cork Harbour, Isaac Carroll. The teeth of the peristome of this plant do not appear twisted, and are much shorter than those of most of the other species.

6. *T. revoluta* (Schwaegr.). Suppl. 1, 127, tab. 32. De Notr. in Mem. Acad., Turin, 40, p. 314, *id.* in Musc. Ital., 1, p. 54, tab. 25. Bryol. Brit., p. 126, tab. 12. Lindberg, Europ. Trichost., p. 40. Barbula revoluta, Bryol. Europ., vol II. Monogr., p. 27, tab. 153. Rabenhor., Bryothec. Europ., No. 422.

Hab. On walls. Abundant near Dublin, and I have observed this moss in most of the counties in Ireland. Rare near Cork, Isaac Carroll.

7. *T. Hornschuchiana* (Schultz), l. c., tab. 33, f. 25. T. Hornschuchiana, De Notr., Syllab., No. 236, and Musc. Ital. 1, p. 55, tab. 28. Bryol. Brit., p. 127, tab. 43. Berk., Handb. Brit. Moss., p. 256. Lindberg, Europ. Trichost., p. 41. Barbula Hornschuchiana, Schimp., Synops., p. 173. Bryol. Europ., vol. II. Monogr., p. 28, tab. 148. Rabenhor., Bryothec. Europ., No. 671.

Hab. Walls and rocks. On the walls of the old castle at Carrickfergus, Antrim. In a quarry near Inchiquin, Cork, Isaac Carroll. Very rare in Ireland.

8. *T. convoluta* (Hedw.). Stirp. 1, p. 86. T. convoluta, Schrad., Spicil. Fl. Germ., 1, p. 66. Engl. Bot., tab. 2382. Muscol. Brit., Ed. 2, p. 54. Bryol. Brit., p. 127, tab. 12. De Notr., Syllab., No. 234. Musc. Ital., 1, 53, tab. 25, Lindberg, Europ., Trichost., p. 40. Barbula convoluta, Rabenhor., Bryothec. Europ., No. 229.

Hab. On walls and on hard ground. This plant is generally distributed through many parts of Ireland, especially in the eastern and southern counties. The variety *β. Sardoa* Wils. was found near Luttrelstown, Dublin, by Dr. Taylor.

9. *T. cuneifolia* (Dickson). Bryum cuneifolium Dicks., Plant, Crypt. Brit., Fasc. 3, p. 7. Turner, Muscol. Hibern. Spicil., p. 51. Muscol., Brit., Ed. 2, p. 59. De Notr., Syllab., No. 223. Muscol. Ital. 1, p. 28, tab. 10. Bryol. Brit., p. 128, tab. 12. Rabenhor., Bryothec. Europ., No. 821. Barbula cuneifolia, Schimp., Synop. Muscor., p. 182.

Hab. On banks and on the ground, generally near the sea. North side of the Hill of Howth, D. Orr. Near Bantry, Miss Hutchins, Fl. Hib. On the side of the public road near Portarlington, Queen's County, July, 1862. This plant is rare in Ireland, and has not yet been observed in the northern or western counties.

10. *T. Vahliana* (Schultz). Recens. 222, tab. 34, f. 34. De Notr., Musc. Ital. 1, p. 27, tab. 8. T. oblongifolia, Bryol. Brit., p. 129, tab. 43. *Var. β. subflaccida,'* Lindberg. Barbula Vahliana, Bryol. Europ. vol. II. Monogr., p. 33, tab. 157.

Hab. On mud banks near Dublin, Drummond, 1829. Near Bray, D. Orr, March, 1851. Near Blanchardstown, and other places near Dublin. The variety *β. subflaccida* is the plant which grows mostly about Dublin, but the plant found at Bray has the firm leaves of the normal state of the species, only the mucros at their points are shorter than those of foreign examples.

11. *T. muralis* (Timm.). Fl. Megapol., p. 220. Turner, Muscol. Hib., p. 50. Muscol. Brit., Ed. 2, p. 55. Bryol. Brit., p. 130, tab. 12. Barbula muralis, Bryol. Europ., vol. II. Monogr. p. 35, tab. 159.

Hab. Walls and banks. The commonest species of Tortula in this country, varying greatly in size and general appearance, according to the habitats where it grows.

12. *T. unguiculata* (Hedw.).—De Notr., Syllab., No. 932. Briol. Ital., p. 548. Muscol. Brit., Ed. 2, p. 57. Bryol. Brit., p. 24, tab. 12. Turner, Musc. Hib., p. 45. Barbula unguiculata, Bryol. Europ., vol. II. Monogr. p. 18, tab. 142–143.

Hab. On walls, rocks, and earth-banks. One of the commonest of all mosses in Ireland, varying considerably in size and general appearance, according to the nature of the localities where it grows.

13. *T. fallax* (Hedw.).—De Notr. Musc. Ital., 1, p. 58, tab. 29. Bryum imberbe, Huds., Fl. Angl., Ed. 1, p. 409. Barbula fallax, Hedw., Stirp. Crypt. 1, p. 62, tab. 24. T. fallax, Muscol. Brit., Ed. 2, p. 60. Bryol. Brit., p. 123, tab. 12.

Hab. Banks and damp walls. Frequent in many places through Ireland. Like many other kinds, it varies much in general appearance, and frequently resembles the nearly allied species which often grow with it.

14. *T. vinealis* (Bridel).—Bryol. Brit., p. 124, tab. 10. De Notr., Musc., Ital. 1, p. 60, tab. 30. Lindb., Europ. Trichost., No. 38. Barbula vinealis, Bridel. Bryol. Univ. 1, Suppl., p. 830. Bryol. Europ., vol. II. Monogr., p. 24, tab. 10. Rabenhor., Bryothec. Europ., No. 668. Spruce, in Hooker's "Lond. Journal of Bot.," vol. IV., p. 194.

Hab. On walls and rocks. Not rare near Dublin. Bray, and several other places, Wicklow. At Hazelwood, and on Benbulben rocks, Sligo. Common at Cork, and near Fermoy, Isaac Carroll. Probably frequent in other limestone districts of Ireland.

15. *T. spadicea* (Mitten). Seemann's "Journal of Bot.," vol. v., 1867, p. 326. Braithwaite in ditto, vol. IX., for 1871, tab. 119, f. 6. Trichostomum rigidulum, var *a*, Bryol. Europ. vol. II., Monogr., p. 10, tab. 176. Schimper, Synops., p. 148. Bryol. Brit., p. 114. Wilson, Musc. Exsic., No. 109.

Hab. Moist rocks and stones. Observed in Ireland by Miss Hutchins, *fide* Mitten.

16. *T. rigidula* (Mitten) in Seemann's "Journal of Botany," vol. v., 1867, p. 327. Lindberg, Europ. Trichost., p. 42. Braithwaite, in Seemann's "Journal of Bot.," vol. VI., 1871, tab. 119, f. 5. Trichostomum rigidulum, Turn., Musc. Hib., p. 34. Bryol. Brit., p. 114. Didymodon rigidulum, Muscol. Brit., p. 117, tab. 20.

Hab. On wet clay banks. Waterfall at Powerscourt; in "The Glens," Antrim; Benbulben, Sligo; and many other places through the country.

"It is only when the lid of the capsule is carefully removed that the top of the teeth of the peristome are seen twisted." Tayl. in Flor. Hib. But the habit of the plant is that of a Tortula.

17. *T. insulana* (De Notr.). in Mem. Acad., Turin, pp. 40, 320, *id.* Syllab., p. 180. Braithwaite, in Seemann's "Journal of Bot." vol. IX., 1871, p. 292, tab. 120. T. vinealis, *β. flaccida.* Bryol. Brit., p. 124. Barbula vinealis, *β. flaccida*, Bryol. Europ., vol. II. Monogr., p. 24. Rabenhor., Bryothec. Europ., No. 982. Zygotrichia cylindrica, Tayl. in Fl. Hib., p. 26.

Hab. By the side of the Dargle River, Co. Wicklow, Fl. Hib. Also in the south of Ireland. De Notr. includes this under T. vinealis in Briol. Ital., p. 555; but Mr. Mitten has proved their distinctness.

18. *T. reflexa* (Bridel). Sp. Musc. 1, p. 255. T. recurvifolia, Wilson, in "Annal. Nat. Hist.," Ser. 3, II., p. 491. Braithwaite, in Seemann's "Journal of Bot.," vol. IX., 1871, p. 293, tab. 120, f. 2. T. recurvifolia, Berk., Handb. Brit. Mosses, p. 258. Barbula recurvifolia, Schimp., Synop., p. 170. Rabenhor., Bryothec. Europ., No. 324.

Hab. On limestone rocks and banks. At Muckross, Killarney, Dr. Schimper and W. Wilson, 1865. This very distinct species grows to a great size on the limestone rocks at Benbulben, Sligo, with stems 3–4 inches long, in which state it bears a close resemblance to Grimmia gigantea of Schimper's Synops., p. 695, and is the plant which Mr. Mitten mistook for that species in Seemann's "Journal of Bot.," vol. v., p. 326. The true Grimmia gigantea has not yet been found in Ireland.

19. *T. subulata* (Bridel). Spec. Musc., vol. I., p. 267. Bryum subulatum. Linn. Spec. Plant. T. subulata (Hedw.).—Eng. Bot., tab. 1101. Muscol. Brit., Ed. 2, p. 57. Bryol. Brit., p. 132, tab. 12. De Notaris, Briol. Ital., p. 545. Lindberg, Europ. Trichost., p. 33.

Hab. Chiefly on banks by the sides of hedges and trees, but sometimes on stones and walls. Rather generally distributed through Ireland, but nowhere very common.

20. *T. latifolia* (Bruch). T. latifolia, Hartm., Skand. Fl., Ed. 2, p. 322. Bryol. Brit., p. 133, tab. 43. Barbula latifolia, Bryol. Europ., vol. II. Monogr., p. 41, tab. 164. C. Müll., Synops. 1, p. 632. Rabenhor, Bryothec. Europ., No. 418. Syntrichia latifolia (Bruch), MS. Hübener, Muscol. Germ., p. 342.

Hab. Among the roots of trees and on wood which is frequently submerged, by the sides of streams, &c. On old wood by the margin of the Tolka River, and in the Botanic Garden, Glasnevin, D. Orr. By the side of the River Lee, near Cork; and probably elsewhere, but in consequence of it seldom fruiting, and having considerable resemblance to some of the other species, it may be often passed unnoticed. Var. *β. mutica*. Schultz, on trees, Deer Park, Westaston, Co. Wicklow.

21. *T. lævipila* (Bridel). T. lævipila, Schwaegr. Suppl. 2, tab. 120. Hartmann, Skand. Fl. Bryol. Brit., p. 133, tab. 43. T. ruralis, *β. lævipila*, Hook. and Grev., Barbula lævipila. Bryol. Europ., vol. II. Monogr., p. 40, tab. 164. Syntrichia lævipila, Bridel, Mant., p. 98.

Hab. Trunks of trees and on bushes. A common moss in nearly every part of Ireland.

22. *T. ruralis* (Linn.).—Muscol. Hib., p. 50. Muscol. Brit., p. 56. Bryol. Brit., p. 134, tab. 12. De Notr., Syllab, No. 217. Musc. Ital. 1, p. 35, tab. 14. Barbula ruralis, Bryol. Europ., vol. I. Monogr., p. 42, tab. 152. Bryum rurale, Linn., Sp. Plant, 1, Ed. 2, p. 1116.

Hab. Roofs of thatched cottages, walls and rocks. A common Moss in every part of Ireland, growing sometimes very large, and varying in size and appearance according to the nature of the place where it grows.

23. *T. intermedia* (Bridel). Rabenhor., Bryothec. Europ., No. 1016. T. ruralis, *δ. crinita.* De Notr., Syllab., No. 217. T. ruralis, *β. minor.* Wils., Bryol. Brit., p. 134. Barbula ruralis, *β. rupestris*, Bryol. Europ., vol. II. Monogr., p. 43. Schimp., Synop. Muscor., p. 192. Syntrichia intermedia, Brid., Bryol. Univ. 1, p. 586.

Hab. On rocks and walls. A plant agreeing with the character given for this species grows on the limestone rocks at Castle Taylor, Galway.

24. *T. papillosa* (Wils.). Bryol. Brit., p. 135, tab. 44. Lindberg, Europ. Trichost., p. 36, No. 23. Barbula papillosa. Rabenhor., Bryothec. Europ., No. 455.

Hab. On the trunks of trees. On old elm trees in Botanic Garden, Glasnevin; Sheephill demesne, Dublin; Powerscourt, Co. Wicklow; Castle Taylor, Galway. Probably not rare elsewhere in Ireland.

25. *T. princeps* (De Notr.). Syllab., No. 216. Musc. Ital., 1, p. 33, tab. 13 Rabenhor., Bryothec. Europ., No. 326. T. Mülleri, Wilson, Bryol. Brit., p. 34, tab. 44. Barbula, Mülleri, Bryol. Europ., vol. II. Monogr., p. 44, tab. 168.

Hab. Rocks and walls. On the basaltic rocks in Deer Park, Glenarm, county of Antrim. Limestone rocks at Benbulben, Sligo. Rare in Ireland.

26. *T. tortuosa* (Hedw.). Fil. in Web. et Mohr, Beitr. 1, p. 125, tab. 6. De Notr., Syllab., No. 243. Musc. Ital., 1, 66, tab. 39. Muscol. Hib., p. 52. Muscol. Brit., p. 59. Bryol. Brit., p. 125, tab. 12. Barbula tortuosa, Br. et Schimp., Bryol. Europ., vol. II. Monogr. 56, tab. 151.

Hab. Rocks and banks chiefly in limestone districts. This moss sometimes grows to a large size, in which state it seldom bears fruit. The fruiting plants are generally of a small or medium size.

27. *T. Hibernica* (Mitten), in Seemann's "Journal of Botany," vol. v., p. 329, 1867. Braithwaite, in ditto, vol. IX., p. 294, tab. 120, f. 5, 1871. Anœctangium Hornschuchianum, Bryol. Brit., p. 294. Trichostomum, cirrhifolium, Schimp., MS. Didymodon controversus, Wils., MS.

Hab. Rocks in mountainous parts of the country. Dr. Taylor first recognised this moss about Killarney and Dunkerron, and mistook it for Anœctangium Hornschuchianum of Hoppe. In 1861 I had the pleasure of pointing it out to Dr. Schimper and Mr. Wilson, at Killarney; and in the following year I observed it growing on Brandon mountain, Kerry. It has never yet been seen in fruit, so that its place in the genus Tortula is only provisional.

28. *T. sinuosa* (Wilson), MS. *fide* Mitten, in Seemann's "Journal of Botany," vol. v., p. 327, 1867. Dicranella sinuosa, Wils. Braithwaite, in Seemann's "Journal of Bot.," vol. IX., p. 294, tab. 120, f. 6, 1871.

Hab. On limestone rocks and also on roots of trees. The Phœnix Park, D. Orr. Between Portmarnock and Malahide. The plant here referred to, T. sinuosa, has, like the last species, only been found in a barren state, and may belong to a different genus. It bears a close resemblance to Weissia tenuirostris, of Hooker and Taylor.

29. *T. fragilis* (Hook.). Didymodon fragilis, Hook., in Drummond, Musc. Amer., 1828. Tortula fragilis, Wils. *fide* Braithwaite, in Seemann's "Journal of Bot.," vol. v., p. 295, 1871. Lindberg, Europ. Trichost., p. 46. Barbula fragilis, De Notr., Musc. Ital., 1, p. 68, tab. 35. Bryol. Europ., vol. VI., suppl. 1, tab. 639.

Hab. On rocks and stones. Near Roundstone, Connemara. Barren specimens of this moss were collected by me in 1861, and sent to Mr. Wilson, who could not then decide what it was; but our plant has since been identified, and proves to be the true species.

30. *T. squarrosa* (De Notr.). Syllab., p. 180, et Muscol. Ital. 1, p. 61, tab. 31. Bryol. Brit., p. 126, tab. 43. Bridel, Bryol. Univ. 1, p. 833. Schimp., Synops., p. 180. Rabenhor., Bryothec. Europ., No. 457. Pleurochæte squarrosa, Lindberg, Europ. Trichost., p. 47.

Hab. On limestone rocks and sand-hills. Sands at Portmarnock, Dr. Taylor. Between Malahide and Portmarnock, Dublin; Arklow, Wicklow. Not hitherto observed elsewhere in Ireland.

[31. *T. gracilis* (Hook. et Greville), in Brewster's "Edinb. Journal," vol. I., p. 300. Muscol. Brit., Ed. 2, tab. suppl. 2. Fl. Hib., p. 26. The late Mr. James Drummond is mentioned as the discoverer of this plant near Cork, but no authentic Irish specimens of it are known to be in any herbarium, and it is now supposed that a variety of T. fallax was mistaken for it. The late Mr. Wilson, in his "Bryologia Britannica," expressed some doubt whether the genuine Barbula gracilis of Schwaegr. (Suppl. 1, p. 125, tab. 34; De Notr., Musc. Ital., 1, p. 57, tab. 28), had been found in Britain or Ireland. The species therefore is placed at the end of our list, as being a very doubtful native.]

Sect. 6. Encalypteæ, Calyptra large, covering the mature capsule.

35. *Encalypta.* Schreber.

Calyptra large, cylindrical, campanulate, apex attenuate-rostrate. Capsule long pedicellate, erect, oblong, or oblong-cylindrical, smooth or striated; lid conical at the base, with a filiform beak. Peristome variable, either absent, single, or double. Outer peristome of 16-teeth; inner peristome, when present, of an equal number of cilia. Leaves mostly large, and spreading equally, varying from linear to oblong, and spathulate; areolation small, roundish and granular. Inflorescence monoicous or dioicous.

Diagnosis of Species.

Inflorescence dioicous. Peristome double.

Capsule spirally striated, ... 1. E. STREPTOCARPA.

Inflorescence monoicous. Peristome single.

Capsule smooth; calyptra fringed at the base, 2. E. CILIATA.

Capsule striated, ribbed; calyptra uneven at the base, ... 3. E. RHABDOCARPA.

Capsule smooth; calyptra entire at the base, 4. E. VULGARIS.

1. *E. streptocarpa* (Hedw.). Spec. Musc., p. 62, tab. 10, Bryol. Europ., vol. III., Monogr., p. 15, tab. 205. Bryol. Brit., p. 145, tab. 13. Muscol. Brit., p. 62. Rabenhor., Bryothec. Europ., No. 681.

Hab. On limestone, or mortared walls. Very large and fine on the tops of walls by the side of the public road leading from the town of Galway to Ahascragh. Also about Killarney. Cork, Dr. Power, in Fl., Cork; and in many other parts of the country; but never yet, I believe, found fruiting in Ireland.

2. *E. ciliata*) Hedw.). Spec. Musc., tab. 61. Bryol. Europ., vol. III. Monogr., p. 10, tab. 200. Wilson, Bryol. Brit., p. 143, tab. 13. Müll., Synop. Musc., pt. 1, p. 547. Muscol. Hib., p. 18. Rabenhor., Bryothec. Europ., No. 255.

Hab. On rocks in the more subalpine parts of the country. Very fine on the top of Benbradagh mountain, near Dungiven, Derry, 1834. Also at Sillagh-braes, near Larne, Antrim. Not observed in any of the southern or western counties, nor have I seen any specimens of this moss except from the north.

3. *E. rhabdocarpa* (Schwaegr.). Suppl., tab. 16. Greville's Crypt. Fl., tab. 163. Bryol. Europ., vol. III. Monogr., p. 13, tab. 203. Bryol. Brit., p. 144, tab. 32. Muscol. Brit., p. 64. Rabenhor., Bryothec., No. 70.

Hab. On Benbulben, Co. Sligo, Fl. Hib., found by J. T. Mackay. Not hitherto observed elsewhere in Ireland?

4. *E. vulgaris* (Hedw.). Spec. Musc., p. 60. Bryol. Europ., vol. III. Monogr., p. 10, tab. 199. Bryol. Brit., p. 142, tab. 13. Schimp., Synop. Muscor., p. 286. Muscol. Brit., Ed. II., p. 63.

Hab. On walls and rocks. On the tops of walls near Donnybrook, County of Dublin; also near Cloghrane, north of Dublin. On walls near the town of Galway. About Cork. Dr. Taylor, in Fl. Hib., Blackrock, near Cork; Dr. Alexander, Middleton; Dr. Power, in Fl. Cork.

Sub-Tribe. RIPARIEÆ.

36. CINCLIDOTUS. Beauvois.

Calyptra conico-attenuate, split at side. Capsule ovate, immersed in the leaves, or partially exserted. Peristome single of 32 long filiform teeth, which are slightly twisted, and adherent by their apices to the columella; often reticulately anastomosing, sometimes obsolete or deficient. Leaves spreading or falcate-secund and thickened at the margin. Water mosses, with long soft stems and leaves, adhering to stones, rocks, and wood.

1. *C. fontinaloides* (Beauv.). Prodr., p. 52. Bryol. Europ., vol. III. Monogr., p. 9, tab. 277. Bryol. Brit., p. 139, tab. 11. Rabenhor., Bryothec., Europ., No. 133.

Hab. In rivulets and streams, attached to stones and wood. The scarce *C. riparius*, known in England only under the form *β. terrestris* of Bruch and Schimper, though reported to occur in Ireland, has not come under my notice.

Tribe 6. ORTHOTRICHEÆ.

37. ORTHOTRICHUM. Hedw.

Calyptra large, campanulate, plicate, lacerate, or crenate, at the base; glabrous or hairy. Capsule immersed or exserted, pyriform, clavate, apophysate, 8 or 16-ribbed when dry. Peristome single or double, rarely absent. Outer peristome of 16-teeth, mostly in pairs, with a medial line; inner, 8 or 16 cilia, alternating with the outer teeth. Leaves costate almost to the points, usually revolute at their margins; often twisted and curled when dry; areolation small dot-like in upper portion, larger and more pellucid at the base. Inflorescence monoicous or dioicous.

Diagnosis of Species.

a. Peristome single.

Capsule immersed, or slightly exserted.

Capsule with 16 furrows; teeth of the peristome 16, free and equidistant, . .	1. O. CAPULATUM.
Capsule with 16 furrows, alternately long and short, exserted on a pedicel; teeth of peristome 16, geminate, ultimately free,	2. O. ANOMALUM.
Capsule with 8 furrows, chiefly on upper portion, exserted on short pedicel; teeth of peristome connected in 8 pairs, erect,	3. O. SAXATILE.
Capsule scarcely longer than perichætal leaves, ovate, smooth when fresh, slightly furrowed near the apex when dry; teeth 16,	4. O. STURMII.

aa. Peristome double, outer of 8 teeth.

Capsule slightly exserted, subcylindrical, with 8 ribs; calyptra conical, slightly hairy,	5. O. TENELLUM.
Capsule slightly exserted, obovate; cilia 8 or 16; calyptra campanulate; vaginula hairy, ...	6. O. STRAMINEUM.
Capsule sessile, elliptic; calyptra campanulate, smooth; cilia 8, ...	7. O. PUMILUM.
Capsule immersed; calyptra naked, campanulate; cilia 8 or 16; leaves bluntish, .	8. O. PALLENS.
Capsule pear-shaped, striated; calyptra naked; teeth of peristome in 8 pairs; cilia 16; leaves flaccid, spreading, . .	9. O. RIVULARE.

Capsule elliptic-oblong, with narrow ribs, pink coloured close to the lid; cilia 8; calyptra hairy, ... 10. O. AFFINE.

Capsule oblong-pyriform, slightly pedicellate; when dry, oblong-urceolate; cilia of inner peristome rather short and broad; calyptra ferruginous, . . 11. O. FASTIGIATUM.

aaa. Outer peristome of 16 teeth.

Capsule pyriform, faintly ribbed near the mouth; teeth erect when dry; cilia 8; calyptra very hairy, ... 12. O. RUPESTRE.

Capsule oblong-pyriform; teeth reflexed when dry; cilia 16; calyptra hairy, . 13. O. LYELLII.

Leaves with rough diaphanous points, . 14. O. DIAPHANUM.

Capsule obovate, without ribs, whitish coloured; cilia 16; erose-articulate, incurved, ... 15. O. LEIOCARPUM.

Pedicel much exserted above the leaves.

Capsule small, with a short lid; striated when dry; 8-ribbed; teeth 16; red coloured; cilia 16; calyptra campanulate, smooth, 16. O. PULCHELLUM.

Capsule thin; contracted and plicate at the mouth when dry; teeth 16; calyptra hairy, ... 17. O. LUDWIGII.

Capsule pear-shaped, oblong, with distant ribs; teeth 16; calyptra conico-campanulate, very hairy, ... 18. O. DRUMMONDII.

Capsule sub-clavate, striated; teeth 16, in pairs; cilia 8; calyptra campanulate, hairy, ... 19. O. HUTCHINSIÆ.

Leaves much crisped when dry.

Capsule oblong-clavate, broadly striated, tapering into a long slender pedicel, not contracted at the mouth when dry; calyptra glabrous, or nearly so, . . 20. O. CALVESCENS.

Capsule oblong-clavate, with a long neck tapering into the pedicel, widely striated, contracted below the mouth; calyptra campanulate, hairy, ... 21. O. CRISPUM.

Capsule with a short neck, oblong when dry, slightly striated, pedicel rather short; calyptra conico-campanulate, very hairy, 22. O. CRISPULUM.

Capsule ovate-pyriform, widely furrowed, the mouth small, and slightly contracted; cilia 8, of one row of cells; calyptra ribbed, very hairy, ... 23. O. BRUCHII.

Leaves lanceolate, not much dilated at the base, nerved to the apex, bearing a tuft of stellate gemmæ, . . . 24. O. PHYLLANTHUM.

1. *O. cupulatum* (Hoffm.). Deutsch. Flor., vol. II., p. 26. Bryol. Europ., vol. III. Monogr., p. 8, tab. 209. Bryol. Brit., p. 176, tab. 21. Hook. and Grev., in "Edinb. Journal of Science," vol. I., p. 112.

Hab. Rocks and walls, chiefly on limestone formations. Frequent in the counties of Antrim and Derry. Benbulben, Sligo. Near Galway and Cork. Fruit, April and May.

2. *O. anomalum* (Hedw.). Stirp. Crypt., tab. 37. Bryol. Europ., vol. III. Monogr., p. 10, tab. 210. Schimper, Synop. Muscor., p. 262. Wood, in "Phytologist," S. S., vol. IV., p. 354, December, 1860.

Hab. On limestone rocks. Very rare in Ireland. A few specimens of this moss, with the 16-striated capsules, were found by D. Orr on rocks near the Dodder river, at Sallygap. The same plant was also collected on limestone rocks near Armagh by Admiral Jones. Fruit, May.

3. *O. saxatile* (Bridel). Bryol. Univers. 1, p. 275. Wood, in "Phytologist," S. S., vol. V., p. 28 (1861). O. anomalum, (Wilson). Engl. Bot. Suppl., tab. 2696. Turner, Musc. Hib., p. 94. Muscol. Brit., Ed. 2, p. 126, tab. 21.

Hab. Rocks and walls, chiefly on calcareous formations. Abundant in many parts of Ireland, wherever the limestone rocks crop out. Fruit, March to May.

4. *O. Sturmii* (Hornsch. et Hoppe). Crypt. Cent. 2, Decas, 2. Bryol. Europ., vol. III. Monogr., p. 9, tab. 209. Schimp., Synops. Muscor., p. 264, *ex parte*.—Briol. Italiana, p. 300. Rabenhor., Bryothec. Europ., No. 884.

Hab. On rocks by the side of the lake at Luggielaw, Wicklow, 1857. Fairhead, Antrim, 1863.

5. *O. tenellum* (Bruch). Bryol. Europ., vol. III. Monogr., p. 15, tab. 212. Schimp., Synops. Muscor., p. 265. Bryol. Brit., p. 178, tab. 45. Briol. Ital., p. 311. Rabenhor., Bryothec. Europ., No. 1078.

Hab. On trees. Near Bantry Bay, Miss Hutchins. Westaston, Wicklow. Ash trees, at Muckross, Dr. Carrington; Rostellan, Cork, and Tervoe, Limerick, Isaac Carroll.

6. *O. stramineum* (Hornsch.). Bryol. Europ., vol. III. Monogr., p. 23, tab. 218. Schimp. Synops. Muscor., p. 272. Bryol. Brit., p. 180, tab. 45. Briol. Ital., p. 315. Rabenhor., Bryothec. Europ., No. 373.

Hab. On trees. Near Seven Churches; also at Westaston, and near Wooden Bridge, Wicklow; Muckross and Rossbeigh, Kerry, Dr. Carrington.

7. *O. pumilum* (Dickson). Crypt. Fasc. 4, p. 5. Turner, Musc. Hib. 98. Bryol. Brit., p. 178, tab. 45. Rabenhor., Bryothec. Europ., No. 372.

Hab. On trees. Near Kilcock, Meath, Dr. Brown. Near Malahide, fruiting December, 1871.

8. *O. pallens* (Bruch et Schimp.). Bryol. Europ., vol. III. Monogr., p. 24, tab. 218. Bryol. Brit., p. 179, tab. 45.

Hab. On trees, Westaston, Wicklow. Near Galway. Near Cork, Isaac Carroll.

9. *O. rivulare* (Turner). Musc. Hib., p. 96, tab. 8. Bryol. Europ., vol. III. Monogr., p. 25, tab. 219. Bryol. Brit., p. 183, tab. 21. Muscol. Brit., p. 128. Rabenhor., Bryothec. Europ., No. 1077.

Hab. On rocks and stones in rivulets. Dargle River, Wicklow. Cork, frequent, Dr. Taylor, in Fl. Hib. Ballinahassig Glen. Cork, Isaac Carroll.

10. *O. affine* (Schrad.). Spicil. Fl. Germ., p. 67. Bryol. Europ., vol. III. Monogr., p. 17, tab. 216. Bryol. Brit., p. 181, tab. 21.

Hab. On trees. This is one of the most abundant mosses on trees everywhere through all parts of Ireland; fruiting in June and July.

11. *O. fastigiatum* (Bruch). Bridel, Bryol. Univ. 1, p. 785. Bryol. Europ., vol. III. Monogr., p. 18, tab. 216. Bryol. Brit., p. 180, tab. 45. Rabenhor., Bryothec. Europ., No. 892.

Hab. On trunks of trees. In the Demesne at Carton, Maynooth.

12. *O. rupestre* (Schleich.). Crypt. Helv. Exsicc., Cent. 3, No. 24. Bryol. Europ., vol. III. Monogr., p. 19, tab. 217. Bridel. Bryol. Univ. 1, p. 279. Bryol. Brit., p. 181, tab. 21.

Hab. On rocks in subalpine districts. On basaltic rocks near the Giants' Causeway, 1837; Fairhead, Antrim. Rocks at Cromagloun, Kerry, Dr. Carrington. Rare in Ireland.

13. *O. Lyellii* (Hook. et Tayl.). Muscol. Brit., p. 129, tab. 22. Bryol. Europ., vol. III. Monogr., p. 27, tab. 221. Bryol. Brit., p. 183, tab. 22. Rabenhor., Bryothec. Europ., No. 1006.

Hab. On trunks of trees, &c. In fruit at Westaston, Wicklow; also near Roundwood. In many parts of Ireland, but rarely found in fruit.

14. *O. diaphanum* (Schrad.). Spicil. Fl. Germ., p. 69. Bryol. Europ., vol. III. Monogr., p. 25, tab. 219. Bryol. Brit., p. 185, tab. 21. Muscol. Brit., p. 128.

Hab. On trees. This small species grows everywhere through Ireland, and is easily recognised by the white diaphanous points of its leaves.

15. *O. leiocarpum* (Br. et Sch.). Bryol. Europ., vol. III. Monogr., p. 28. tab. 220. Bryol. Brit., p. 186, tab. 21. Rabenhor., Bryothec. Europ., 516. O. striatum Hedw. Turner, Musc. Hib., p. 95. Muscol. Brit., p. 128.

Hab. On trees. In most parts of Ireland. It is easily recognised, by its large, coarse tufts of stems, and by the smooth, whitish, round capsules, when growing among other Orthotrichi.

16. *O. pulchellum* (Smith). Engl. Bot., tab. 1787. Muscol. Brit., p. 134, tab. 21. Bryol. Europ., vol. III. Monogr., p. 30, tab. 223. Bryol. Brit., p. 186, tab. 21.

Hab. On trunks of trees. In Antrim and Derry; Ballinascorney Glen, Dublin; Carton Demesne, Maynooth. Rockingham, near Boyle, Roscommon; Ronayne's Court, and in a grove at Blarney, Murray in Fl., Cork. Not very common in Ireland.

17. *O. Ludwigii* (Schwaegr.). Suppl. 1, 2, 24, tab. 15. Bryol. Europ., vol. III. Monogr., p. 12, tab. 225. Bryol. Brit., p. 187, tab. 34. Ulota Ludwigii, De Notr., Briol. Ital., p. 291. Rabenhor. Bryothec. Europ., No. 519.

Hab. On trees, principally young oaks in subalpine glens. Ireland rare, Wils., Bryol. Brit., p. 187. Oaks at Torc wood and Glena wood, Killarney, Dr. Carrington.

18. *O. Drummondii* (Hook. et Grev.), in "Edin. Journ. of Science," vol. I., p. 120. Muscol. Brit., Ed. 2, p. 126. Bryol. Europ., vol. III. Monogr., p. 12, tab. 210. Bryol. Brit., p. 189, tab. 34. Ulota Drummondii, Bridel., Bryol. Univ. 1, p. 299. Rabenhor., Bryothec. Europ., No. 881.

Hab. On trunks usually of young trees. On trees at Powerscourt Waterfall; Luggielaw; between Roundwood and Anamoe, Wicklow. Near Clonmel, and in Gorton wood, Tipperary, Isaac Carroll. Killarney, and Muckross, Kerry; but not very common anywhere in Ireland.

19. *O. Hutchinsiæ* (Hook. et Taylor). Muscol. Brit., p. 131, tab. 21. Bryol. Brit., p. 190, tab. 21. Bryol. Europ., vol. III. Monogr., p. 20, tab. 226. Ulota Hutchinsiæ, Briol. Ital., p. 290. Rabenhor., Bryothec. Europ., No. 879.

Hab. On rocks in mountainous parts of the country. Luggielaw and Lough Dan, Wicklow. Abundant on rocks about Brandon and Killarney, Kerry. Near Galway and in Connemara. Near Armagh, Admiral Jones.

20. *O. calvescens* (Wilson). Carrington, in Botanical Society of Edinburgh "Transactions," vol. VII., p. 386. Rabenhor., Bryothec. Europ., No. 520.

Hab. On trunks and branches of trees. First observed at Muckross, in 1857. Gathered again both there and at Torc Waterfall, Killarney, in 1864, in company with Dr. Schimper and Mr. Wilson. Several places about Killarney, Dr. Carrington. Glenveigh, Donegal. Glencar, Sligo, 1870. Fruiting in June.

21. *O. crispum* (Hedw.). Sp. Musc., p. 162. Bryol. Europ., vol. III. Monogr., p. 23, tab. 288. Bryol. Brit., p. 188, tab. 21. Ulota crispa, Briol. Ital., p. 288.

Hab. On trees and sometimes on rocks. Very common in many parts of Ireland.

22. *O. crispulum* (Hornsch.). Bryol. Europ., vol. III. Monogr., p. 23, tab. 228. Bryol. Brit., p. 187, tab. 45. Ulota crispula, Bridel, Bryol. Univ. p. 793. De Notr., Briol. Ital., p. 289. Rabenhor., Bryothec. Europ., No. 179.

Hab. On trees. At Killarney, Kerry. Kylemore, Galway. Ballyfin Woods, Queen's County. Dr. Carrington considers this only a small variety of O. crispum.

23. *O. Bruchii* (Bridel). Bryol. Univ. 1, p. 794. Bryol. Brit., p. 188, tab. 45. Rabenhor., Bryothec. Europ., No. 880. O. coarctatum, Bryol. Europ., vol. III. Monogr., p. 21, tab. 227. Ulota Bruchii, Bridel, Bryol. Univ. 1, p. 794.

Hab. On trees. Very frequent in Ireland, and formerly mistaken for O. crispum. On rocks and stones near Clonmel; also on rocks and stones near Cork, Isaac Carroll.

24. *O. phyllanthum* (Bruch et Schimp.). Bryol. Europ., vol. III. Monogr., p. 30, tab. 223. Bryol. Brit., p. 190, tab. 46.

Hab. On trees, more rarely on rocks. Abundant in every part of Ireland, but never yet found fruiting in this country.

38. Zygodon. Hook. et Tayl.

Diagnosis of Species.

Calyptra conico-cuculliform, or attenuate-rostrate. Capsule pedicellate, or immersed; striated, apophysate. Peristome either double, single, or absent; outer teeth 8 or 16; united 2 or 4 together; inner peristome of 8 or 16 cilia, alternating with the outer teeth. Leaves linear-lanceolate, carinate, costate to their points; areolation, small dot-like above, larger and more attenuate below. Inflorescence synoicous, monoicous, or dioicous. Distinguished from Orthotrichum, principally by the cucullate narrow calyptra.

Stems cæspitose; lower leaves oblong; upper lanceolate-acute; capsule turbinate, striated, on a short pedicel, without peristome, dioicous, ...	1. Z. Mougeotii.
Stems tufted, cæspitose; branched dichotomously; leaves dense, subsquarrose, widely spreading, recurved; capsule on a longish pedicel; obscurely striated; lid beaked; peristome wanting, . .	2. Z. viridissimus.
Stems tufted, fastigiate; short and not much branched; leaves spreading, broadly-lanceolate; nerve scarcely reaching to the apex; capsule striated; lid beaked, ...	3. Z. conoideus.

1. *Z. Mougeotii* (Br. and Sch.). Bryol. Europ., vol. III. Monogr., p. 7, tab. 206. Bryol. Brit., p. 192, tab. 46. Amphoridium Mougeotii. De Notr. Briol. Ital., p. 276. Rabenhor., Bryothec. Europ., No. 523.

Hab. On moist shady rocks; frequent in many parts of Ireland, but very rare in fruit. A solitary stem with fruit was found near the head of Glenbally-eman, near Cushendall, Antrim, in June, 1863.

2. *Z. viridissimus* (Bridel). Bryol. Univ. 1, p. 592. Bryol. Europ., vol. III. Monogr., p. 7, tab. 206. Bryol. Brit., p. 193, tab. 6. Amphoridium viridissimum, De Notr., Briol. Ital., p. 277. Gymnostomum viridissimum, Smith, Engl. Bot., tab. 1583. Muscol. Brit., Ed. 2, p. 18.

Hab. On trees usually, but sometimes on rocks. Abundant in the woods at Killarney, where it fruits freely. On rocks near Malahide and near Dunsink, Dublin. Very frequent on trees, but without fruit in most parts of Ireland.

3. *Z. conoideus* (Dickson). Crypt. Fasc. 4, tab. 11, f. 2. Muscol. Brit., p. 123. Bryol. Brit., p. 193, tab. 21.

Hab. Trunks of trees. Frequent in the woods at Killarney, fruiting freely there. Woods at Ballyfin, Queen's County; woods at Powerscourt, Wicklow; and woods at Rockingham, Roscommon; also many other parts of Ireland, but not generally fruiting.

Tribe 7. FUNARIEÆ.

Sect. 1. Capsule entire without operculum.

39. EPHEMERUM. Hampe.

Calyptra conico-campanulate. Capsule roundish, sub-acute at the apex, very shortly pedicellate, entire, not operculate; columella none. Leaves soft, flaccid; areolation loose, cellules rhomboidal. Male flowers gemmiform, at or near the base of the fertile stem.

Diagnosis of Species.

Leaves nerveless, lanceolate, serrated from the middle to the apex, . . .	1. E. SERRATUM.
Leaves with slender nerve, reaching nearly or quite to the apex, serrated from the middle upwards, oblongo-acute, . .	2. E. COHÆRENS.

1. *E. serratum* (Schimp.). Bryol. Europ., vol. I. Monogr., p. 3, tab. 1. Synops. Muscor., p. 3. Rabenhor., Bryothec. Europ., No. 159. Phascum serratum, Schreb., de Phasco., p. 9, tab. 2. Bryol. Brit., p. 26, tab. 5.

Hab. On moist banks and places where water has stood during winter. About Belfast frequent, but rare elsewhere.

2. *E. cohærens* (Hedw.). Sp. Musc., tab. 1, f. 1–6. Bryol. Europ., vol. I. Monogr., p. 4, tab. 1. Schimp., Synops. Muscor., p. 4. Rabenhor., Bryothec. Europ., No. 160. Phascum cohærens, Bryol. Brit., p. 27, tab. 37.

Hab. On wet shady banks. By the side of the River Shannon, near Portumna, Galway, 1865.

40. PHYSCOMITRELLA. Schimp.

Calyptra conico-campanulate, small, entire. Capsule spheroid, apiculate at the apex; columella persistent. Leaves few, placed together at the apex of the very short stem; areolation loose, cellules somewhat hexagonal. Antheridia naked, axillary with paraphyses distended at the apex.

1. *P. patens* (Schimp.). Bryol. Europ., vol. I. Monogr., p. 7, tab. 3 Rabenhor., Bryothec. Europ., No. 161. Phascum patens, Hedw., St. Crypt., 1, tab. 10. Bryol. Brit., p. 34, tab. 5.

Hab. On moist banks near Belfast. Very rare in Ireland.

41. SPHÆRANGIUM. Schimp.

Stems very short, simple. Capsule spherical; peduncle very short, immersed among the leaves; columella distinct. Antheridia without paraphyses, gemmiform.

1. *S. muticum* (Schimp.). Synops. Muscor., p. 13. Phascum muticum, Schreb., de Phasc., p. 8, tab. 1, f. 11, 12. Bryol. Brit., p. 29, tab. 5.

Hab. On moist banks and where water has stood. Frequent about Dunkerron, Kerry, Taylor, in Fl. Hib. Damp sands at Malahide, but rare in Ireland.

Sec. 2. Capsule without peristome.

42. PHYSCOMITRIUM. Bridel.

Calyptra large campanulate-rostrate, lobed at the base. Capsule pedicellate, erect, obovate or pyriform, exannulate. Peristome wanting; lid convex, with or without an apiculus. Leaves of thin texture; areolation loose, composed of oblong thickish cellules; nerve ceasing at or below the apex. Inflorescence monoicous or polygamous.

Diagnosis of Species.

Capsule pyriform; calyptra inflated, split on one side; leaves oblong-lanceolate, acute, thickened at margin, . . .	1. P. ERICETORUM.
Capsule pyriform; calyptra inflated below, split on one side; leaves ovate-oblong acuminate, serrated, not thickened at margin, ...	2. P. FASCICULARE.

Capsule roundish, large; lid conical; calyptra lobed at the base, ... 3. P. PYRIFORME.

1. *P. ericetorum* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 13, tab. 300. Bryol. Brit., p. 273, tab. 7. Gymnostomum fasciculare, Hook. et Tayl. Muscol. Brit., Ed. 2, p. 24. Entosthodon ericetorum, De Notr., Briol. Ital., p. 454. Rabenhor., Bryothec. Europ., No. 22.

Hab. On heaths and on damp ground. Glenmacnass and Glencree, Dublin; Luggielaw and other places Wicklow; Connemara; also in the southern counties, but not very frequent.

2. *P. fasciculare* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 13, tab. 301. Bryol. Brit., p. 274, tab. 52. Gymnostomum fasciculare, Hedw. Sp. Musc., tab. 4. Entosthodon fascicularis, De Notr. Briol. Ital., p. 453. Rabenhor., Bryothec. Europ., No. 353.

Hab. Clayey fields and damp ground. Not very common in Ireland. In "The Glens," and near Belfast, Co. Antrim; Cork and Fermoy, Isaac Carroll.

3. *P. pyriforme* (Br. et Schimp.). Bryol. Europ., vol. III. Monogr., p. 2, tab. 299. Bryol. Brit., p. 275, tab. 7. Gymnostomum pyriforme. Turner, Musc. Hib., p. 11. Engl. Bot., tab. 413.

Hab. Damp ground where water has stood during winter; also on moist banks. Frequent in many parts of Ireland. Very fine on the Murrough of Wicklow.

43. BARTRAMIDULA. Br. et Sch.

Calyptra small, cucullate, fugacious. Capsules more or less cernuous, on curved footstalks, globose, smooth, of thin texture, mouth small. Peristome none, lid disciform. Leaves lanceolate, denticulate; areolation loose, composed of oblong hexagonal cellules. Sporangium united to columella, as in the genus Hymenostomum.

1. *B. Wilsoni* (Br. et Schimp.). Bryol. Europ., vol. IV. Monogr., p. 3, tab. 315. Engl. Bot. Suppl., tab. 2919. Bryol. Brit., p. 276, tab. 52.

Hab. On loose black peaty earth among heath. On Connor-hill, near Dingle; W. Wilson, 1829. Knockavohila Mountain, near Kenmare. Dr. Taylor.

Sect. 3. Capsule with peristome single or double of 16 teeth.

44. ENTOSTHODON. Schwaegr.

Calyptra large, inflated, long-rostrate, cuculliform, split at the side. Capsule on a long pedicel, slightly secund at the apex, symmetrical, pyriform, often narrowed at the mouth; lid flattish, disciform. Peristome none, or single of 16 teeth, inserted below the orifice of the capsule, slightly oblique. Leaves with rather large, loose areolation, cellules oblong-hexagonal, thin, and pellucid.

1. *E. Templetoni* (Schwaegr.). Suppl., tab. 113. Bryol. Europ., vol. III. Monogr., p. 3, tab. 302. Bryol. Brit., p. 272, tab. 14. Funaria Templetoni, Smith, Engl. Bot., tab. 2524. Weissia Templetoni, Hook. and Taylor, Muscol. Brit., p. 77.

Hab. On moist banks and crevices of rocks. In most parts of Ireland. Very abundant in the southern and western counties; also in Wicklow and Antrim.

45. FUNARIA. Schreber.

Calyptra large long-rostrate, split at the side below. Capsule long-pedunculated, erect, arcuate as the fruit approaches maturity, obliquely pyriform, cernuous, with a small oblique mouth. Peristome double, outer teeth 16, oblique, lanceolate-attenuated, connected at their apices by a small reticulated disk; the interior peristome a membrane, divided into 16 lanceolate processes, opposite to the exterior teeth. Leaves remote near base of stem, more crowded upwards, broadly-lanceolate, apiculate or bluntish; areolation loose, cellules large, somewhat oblong-hexagonal, nerves loosely cellular, ceasing below the apex. Inflorescence monoicous or dioicous.

Diagnosis of Species.

Capsule subventricose-pyriform, with the mouth oblique and surrounded by a finely corrugated border of an orange or yellowish colour; outer peristome reddish, inner yellow, ...	1. F. HYGROMETRICA.
Capsule clavate-pyriform; annulus none, inflated at the neck; leaves ovate-oblong, sharply serrated in upper half,	2. F. HIBERNICA.
Capsule sub-erect, shortly pyriform; lid conico-convex, yellowish or brown. leaves widely ovate, bluntly serrated, .	3. F. MÜHLENBERGII.

1. *F. hygrometrica* (Hedw.). Sp. Musc., p. 172. Bryol. Europ., vol. III. Monogr., p. 8, tab. 305. Bryol. Brit., p. 269, tab. 20. Hook. and Tayl., Muscol. Brit., p. 121.

Hab. On banks, walls, and heaths everywhere. Of this beautiful but very common moss, Dr. Taylor remarks in Fl. Hib., that it is not only common in every part of Ireland, but has been observed in every visited part of the globe. It varies very much in appearance according to the localities where it grows. Dr. Taylor considered the two following to be only states of this species.

2. *F. Hibernica* (Hook. et Taylor). Muscol. Brit., p. 122, tab. 20. Bryol. Europ., vol. III. Monogr.. p. 7, tab. 304. Bryol. Brit., p. 270, tab. 20. Rabenhor., Bryothec. Europ., No. 812.

Hab. On limestone soil near Cork, and also near Blarney, Drummond. Rare in Ireland.

3. *F. Mühlenbergii* (Schwaegr.). Suppl., tab. 66. Engl. Bot., tab. 1497. Muscol. Brit., p. 122. Bryol. Brit., p. 271, tab. 20. F. Mediterranea, D. Notr., Briol. Ital., p. 449.

Hab. On calcareous banks and walls. Fermoy, near Cork, T. Chandlee. By the Funcheon, near Glanworth, Cork, Isaac Carroll.

Tribe 8. SPLACHNEÆ.

46. SPLACHNUM. Br. et Schimp.

Calyptra small, conic, entire or irregularly lacerated at base. Capsule long-pedicellated, erect, obovate-oblong, or sub-cylindrical, with a large spongy differently-coloured apophysis; lid convex or mammillate. Peristome single, of 16 teeth, approaching in pairs, erect or reflexed when dry. Columella exserted, capitate. Leaves thin and delicate; areolation loose, composed of oblong-hexagonal cellules, nerve thin, ceasing below the apex. Plants mostly annual, and often growing on the dung of animals. Distinguished chiefly by the large apophysis.

Diagnosis of Species.

Capsule oblong, with a large inversely-urceolate apophysis; lid conico-convex. Inflorescence dioicous, or sub-monoicous, . 1. S. AMPULLACEUM.

Capsule sub-cylindrical, with a roundish-oblong apophysis; peristome half the length of capsule. Dioicous, . . 2. S. SPHÆRICUM.

Capsule urceolate, apophysis scarcely wider than the capsule; teeth of the peristome in eight pairs. Monoicous, . . . 3. S. MNIOIDES.

1. *S. ampullaceum* (Linn.). Sp. Pl., p. 1572. Bryol. Europ., vol. III. Monogr., p. 10, tab. 293. Bryol. Brit., p. 289, tab. 9. Muscol. Brit., p. 39. Rabenhor., Bryothec. Europ., No. 43.

Hab. On bogs and heaths, growing on the dung of herbivorous animals. Frequent in many parts of Ireland.

2. *S. sphæricum* (Hedw.). Stirp. 2, 46, tab. 16. Bryol. Europ., vol. III. Monogr., p. 8, tab. 292. Bryol. Brit., p. 290, tab. 9, Muscol. Brit., p. 36.

Hab. Moist meadows and bogs. On the dung of herbivorous animals. Often found with the former species, and common in Ireland.

3. *S. mnioides* (Linn. fil). Meth. Musc., p. 6, Engl. Bot., tab. 1589. Muscol. Brit., p. 38. Tetraplodon mnioides, Br. et Sch., Bryol. Europ., vol. III. Monogr., p. 5, tab. 289. Bryol. Brit., p. 291, tab. 9. Rabenhor., Bryothec. Europ., No. 65.

Hab. Moist places on mountains, generally on the dung of animals. Near Bantry, Miss Hutchins; near Belfast, Templeton; Brandon, Kerry. Lugnaquillia, Wicklow. Rather rare.

Tribe 9. BARTRAMIEÆ.

47. BARTRAMIA. Hedw.

Calyptra small, dimidiate, fugacious. Capsule on long or short peduncle, sometimes immersed, cernuous, seldom erect or pendulous, mostly furrowed when dry; lid depressed; hemispherical or conic-umbonate. Peristome usually double, more rarely single or none, exterior teeth 16, equidistant, lanceolate; the inner peristome a plicated membrane, divided into 8–16 divergent cilia, with rudimentary ciliolæ sometimes present. Leaves spreading equally, lanceolate or lanceolate-acuminate, papillose, of a firm texture; areolation dense, quadrate. Inflorescence synoicous, monoicous or dioicous.

Diagnosis of Species.

a Inflorescence dioicous, branches fasciculate. (*Philonotis*, Brid. *pars*).

Capsule thick, obovate, curved, striated when dry; perigonial leaves broad at base, concave, obtuse and nerveless, . .	1. B. FONTANA.
Capsule with short neck, nearly umbilicate; perigional leaves with a thick broad nerve, which is more or less excurrent, . .	2. B. CALCAREA.

aa Inflorescence monoicous, branches fastigiate. (*Philonotis*, Brid. *pars.*)

Stem erect, with very short fasciculate branches; leaves upright, dentate, lanceolate-subulate, cells at base enlarged, ...	3. B. CÆSPITOSA.
Capsule obliquely cernuous, on a rather long pedicel. Male flowers gemmaceous, approximate to female flowers, . .	4. B. RIGIDA.

b Inflorescence synoicous, branches not fasciculate.

Capsule globose, oblique, elevated on a rather long pedicel, lid plano-convex, .	5. B. OEDERI.
Capsule on an elongated pedicel, oblique; processes of the inner peristome imperfect, ...	6. B. ITHYPHYLLA.

bb Inflorescence monoicous.

Capsule on a short pedicel, which is scarcely longer than the leaves of stem, . .	7. B. HALLERIANA.
Capsule sub-globose, elevated on a pedicel considerably above the leaves of stem, .	8. B. POMIFORMIS.

c Inflorescence dioicous, leaves plicate. (*Breutelia*, Schimp.).

Capsule on short pedicel spheroid, arcuate. Barren flowers, discoid, ...	9. B. ARCUATA.

1. *B. fontana* (Bridel). Bryol. Univer., 2, p. 20. Bryol. Europ., vol. IV. Monogr., p. 18, tab. 324. Bryol. Brit., p. 279, tab. 23. Muscol., Brit., p. 146. Philonotis fontana, De Notr., Briol. Ital., p. 256.

Hab. In wet boggy places. This very common and handsome moss is abundant in most parts of Ireland, especially in upland moory districts, varying much in height of stems and breadth of leaves. The most distinct form among the varieties is that described as var. *falcata*, by De Notaris, Wilson, and Bridel. It was collected on the ascent of Lugnaquillia Mountain, Wicklow, in 1867.

2. *B. calcarea* (Br. et Sch.). Bryol. Europ., vol. IV. Monogr., p. 19, tab. 325. Bryol. Brit., p. 281, tab. 52. Philonotis calcarea, Schimp., Synop. Muscor., p. 427. Briol. Ital., p. 256. Rabenhor., Bryothec. Europ., No. 130.

Hab. Sides of streams and wet places, especially in limestone districts. Near Ballyfin, Queen's-County; Benbulben, Sligo; Glenmalur, Wicklow; near Looscanagh Lake, and at Glena, Killarney, Dr. Carrington.

3. *B. cæspitosa* (Wils.) *fide* Hunt, in "Memoirs of the Literary and Philosophical Society of Manchester," Third Series, vol. III., p. 239 (1867).

Hab. On damp ground. By the side of a stream on the ascent from the Hotel, at Glenmalur, towards Kelly's Lake, County of Wicklow. Having collected this species near Warrington in company with the late Mr. Wilson, I observed it the following year in Wicklow and sent specimens to Mr. Wilson, who confirmed my identification.

4. *B. rigida* (Bals. et De Notr.). Pugill., No. 1. Bryol. Europ., vol. IV. Monogr., p. 20, tab. 326. Bryol. Brit., p. 278, tab. 52. Philonotis rigida, Schimp., Synops. Muscor., p. 424. Briol. Ital., p. 259. Rabenhor., Bryothec. Europ., No. 1018.

Hab. Damp shady banks and rocks. By the side of the river in Maghanabo Glen, near Castlegregory, Kerry; W. Wilson and D. M. Between Kenmare and Killarney; Dr. Taylor and D. M. Very fine on shady rocks between the Wooden Bridge and Arklow, Wicklow, May, 1867-8. Rare in Ireland.

5. *B. Oederi* (Swartz.) in Schräder "Journal" (1800). Bryol. Europ., vol. IV. Monogr., p. 12, tab. 318. Bryol. Brit., p. 283, tab. 23. Rabenhor., Bryothec. Europ., 368. Bartramia gracilis, Hook. and Tayl., Muscol. Brit., p. 146, tab, 23.

Hab. Shady rocks in subalpine districts. Collon Glen, near Belfast; Deer Park, Glenarm, Antrim; Brandon Mountain, Kerry. Rare in Ireland.

6. *B. ithyphylla* (Bridel). Bryol. Univer., 2, p. 43. Engl. Bot., tab. 1710. Muscol. Brit., p. 145. Bryol. Europ., vol. IV. Monogr., p. 44, tab. 317. Rabenhor., Bryothec. Europ., No. 234. Bryol. Brit., p. 282, tab. 23.

Hab. Rocks in the more mountainous parts of the country. Frequent on the basalt, in Antrim; Lough Bray, and Dargle, Wicklow, Dr. Taylor.

7. *B. Halleriana* (Hedw.). Stirp. Crypt., ii., tab. 40. Engl. Bot., tab. 997. Muscol. Brit., p. 147. Bryol. Europ., vol. IV. Monogr., p. 14, tab. 320. Bryol. Brit., p. 281, tab. 23. Rabenhor., Bryothec. Europ., No. 235.

Hab. Shady rocks in subalpine parts of the country. Collon Glen, near Belfast; Tayl. in Flor. Hib., and I have collected good examples in the same locality. Rare in Ireland.

8. *B. pomiformis* (Hedw.). Sp. Musc. 164. Muscol. Brit., p. 144, tab. 23. Engl. Bot., tab. 998. Bryol. Europ., vol. IV. Monogr., p. 13., tab. 319. Bryol. Brit., p. 281, tab. 23.

Hab. On dry banks and rocks. This moss, which is rather common in many parts of the country, makes its presence known to the muscologist by its pretty globular capsules elevated on longish pedicels crowded in roundish tufts. The var. *β. crispa* grows with stems from 3 to 6 inches long on Brandon, and also at Cromagloun, Kerry, but I never could find it producing fruit in that state.

9. *B. arcuata* (Bridel). Muscol. 4, p. 139. Engl. Bot., tab. 1237. Hook. and Tayl., Muscol. Brit., p. 148. Bryol. Europ., vol. IV. Monogr., p. 15, tab. 321. Bryol. Brit., p. 283, tab. 23. Breutelia arcuata, Schimp., Synops. Muscor., p. 427. Briol. Ital., p. 260.

Hab. On damp boggy ground and shaded rocks, This is a very abundant moss in most parts of Ireland, particularly so in the hilly districts, and frequently to be met with in fruit. When growing, as it does in parts of Kerry, with stems upwards of 6 inches long, it is a very handsome species.

Tribe 10. Bryeæ.

48. Bryum. Hook. et Tayl.

Calyptra small, cuculliform, fugacious. Capsule pyriform, clavate or oblong, often nutant or pendulous, with a tapering neck or apophysis, exserted on a long footstalk. Peristome double, the exterior of 16 equidistant teeth, with a flexuose medial line, hygroscopic; articulation close and prominent; inner peristome a membrane divided into 16 processes or cilia, more or less perfect, and alternating with the outer teeth, ciliolæ when present, one to three together. Leaves spreading, more or less decurrent and amplexicaul at base, inclined to ovate or lanceolate, costate; areolation rather large, and rhomboidal. Inflorescence various, male flowers with filiform paraphyses.

Wilson's arrangement of the species of this genus is followed here, as being easily understood, though differing from that of continental muscologists.

Diagnosis of Species.

a. Leaves narrow, erect, nerve ceasing below the apex.

* Capsule narrow, inclined.

Inflorescence monoicous.

Capsule slender clavate, with a long tapering neck, inclined horizontally; lid conical; peristome large, with the outer teeth incurved when dry, ...	1. B. acuminatum.
Capsule oblong, pyriform, slightly inclined, neck shorter than the sporangium; peristome wanting the inner cilia; outer teeth reddish, incurved when dry, .	2. B. polymorphum.
Stems short; leaves erect, lanceolate-acuminate, serrated; capsule elongate, clavate, inclined; peristome with inner cilia more or less complete, ...	3. B. elongatum.

Inflorescence synoicous or dioicous.

Stems simple; leaves lanceolate, erect, rigid serrulate, nerve not quite percurrent; capsule oblong-pyriform, cernuous, lid rather apiculate, ...	4. B. crudum.

** Capsule pyriform pendulous.

Inflorescence monoicous or synoicous.

Stems short; lower leaves ovate-lanceolate, entire; upper leaves acuminate, serrated, at their points; capsule oblong-pyriform; lid apiculate, . . . 5. B. NUTANS.

Inflorescence dioicous.

Stems loosely cæspitose, leaves lanceolate, serrated at the apex; capsule pyriform with a long tapering neck, . . . 6. B. ANNOTINUM.

Stems simple; leaves ovate-lanceolate, nerved nearly to the apex; capsule obovate, subpendulous; lid apiculate, . . 7. B. CARNEUM.

Leaves ovate, nerve ceasing below the apex.

Stems more or less decumbent at the base; leaves ovate-acuminate, serrated at the apex, nerve not excurrent; capsule exannulate, peristome large, . . 8. B. WAHLENBERGII.

aa. Leaves mostly ovate, nerved to the apex.

Inflorescence synoicous or monoicous.

Stems branched, loosely tufted; leaves ovate acuminate, margin recurved, nerved to the apex; capsule pyriform, pendulous, 9. B. WARNEUM.

Inflorescence dioicous.

Stems elongated erect, sparingly branched; leaves spreading, subdecurrent, concave, with a slight border; capsule oblong-subcylindrical; lid mammillate, . 10. B. PSEUDOTRIQUETRUM

Stems rigid; leaves imbricated, erect, margin recurved, subserrulate, nerve excurrent; capsule oblong-ovate, pendulous, 11. B. ALPINUM.

Stems loosely cæspitose, slender; leaves ovate-acuminate, nearly entire, decurrent, margin slightly recurved; capsule subclavate, pyriform, pendulous, . . 12. B. PALLENS.

Stems lax and often spreading; leaves ovate acute, nerve excurrent or cuspidate; capsule shortly-pyriform, pendulous, contracted below the mouth when dry, . 13. B. Duvalii.

aaa. Leaves ovate, nerve excurrent.

Inflorescence monoicous.

Stems short, branched; leaves ovate-lanceolate, margin partly reflexed; capsule clavate, mouth small; oblique, . . 14. B. uliginosum.

Stems cæspitose, branched and radiculose; leaves ovate-lanceolate, nerved scarcely to the apex; capsule oblong-pyriform, constricted below the mouth, . . 15. B. pallescens.

Inflorescence synoicous.

Inner peristome imperfect.

Stems tufted, radiculose; leaves concave, ovate-acuminate; capsule pyriform; mouth small; lid conical, . . . 16. B. pendulum.

Stems short, radiculose; leaves ovate-lanceolate, nerve excurrent; capsule ventriose-pyriform; lid with a sharp apiculus, . 17. B. inclinatum.

Inner peristome perfect.

Stems cæspitose, branched, radiculose; leaves spreading, ovate-lanceolate; capsule clavate-pyriform, subpendulous; inner peristome with appendiculate cilia, . 18. B. intermedium.

Stems elongated; leaves oblong-acuminate, margins recurved, nerve excurrent; capsule pendulous; lid large, mammillate, ... 19. B. bimum.

Stems loosely cæspitose; leaves ovate-lanceolate, entire, twisted when dry, their margin reflexed; capsule obconical subpendulous; lid apiculate, . . . 20. B. torquescens.

Inflorescence dioicous.

Stems densely cæspitose; leaves ovate, twisted when dry, nerve excurrent into a hair-like point; capsule oblong-pendulous, . 21. B. capillare.

Stems short radiculose; leaves erecto-patent, lower on the stem-oblong-acute, upper obovate, elongate-acute with a narrow thickened border, nerved to the apex; capsule oblong-cylindrical, subpendulous; lid apiculate, . . 22. B. DONIANUM.

Stems branched, radiculose; leaves spreading, ovate-acuminate, nerve excurrent; capsule oblong-ovate; lid large mammillate, ... 23. C. CÆSPITITIUM.

Stems short; leaves ovate-lanceolate, cuspidate, nerve shortly excurrent; capsule oblong-pyriform; lid apiculate, . . 24. B. ERYTHROCARPUM.

Stems short, branched; leaves ovate-lanceolate; nerve sub-excurrent; capsule roundish, constricted below the lid, . 25. B. ATROPURPUREUM.

aaaa. Leaves concave, closely imbricated, nerve mostly ceasing below the apex.

† Capsule symmetrical.

Stems slender, cæspitose; leaves closely imbricated, concave, ovate, entire, nerve reaching to the apex; capsule obovate-cylindraceous, pendulous, . . . 26. B. JULACEUM.

Stems branched, cæspitose; leaves ovate-apiculate, imbricated, concave, nerve ceasing below the apex; capsule pendulous; lid mammillate, . . . 27. B. ARGENTEUM.

†† Mouth of the capsule oblique.

Stems short, with short innovations; leaves closely imbricated, concave, ovate-acuminate, entire, nerve scarcely excurrent; capsule clavate, cernuous, . . . 28. B. ZIERII.

aaaaa. Leaves broad, roundish.

Stems gregarious, short; the lower leaves narrowly obovate, upper broadly obovate, apiculate, bordered, nerved half way; capsule more or less drooping, obovate or pyriform, ... 29. B. TOZERI.

aaaaaa Leaves very large, collected in a rosaceous tuft at apex of stem.

Stem decumbent at base; leaves patent, obovate-spathulate, serrated, waved; nerve excurrent; capsule pendulous, oblong-ovate, ... 30. B. ROSEUM.

1. *B. acuminatum* (Br. et Schimp.) Bryol. Europ., vol. IV. Monogr., p. 21, tab. 342, 343. Bryol. Brit., p. 221., tab. 47. Webera acuminata, De Notr., Briol. Ital., p. 428. Pohlia acuminata, Hornsch., in Neu Bot. Zeit., 2, p. 94.

Hab. On the rocky sides of mountain streams. Brandon, Kerry; Toole's rocks, Wicklow.

2. *B. polymorphum* (Br. et Schimp.). Bryol. Europ., vol. IV. Monogr., p. 25, tab. 344. Bryol. Brit., p. 222, tab. 47. Webera polymorpha, De Notr., Briol. Ital., p. 428. Pohlia polymorpha, Hornsch., et Hopp. Bot. Zeit., 2, p. 100.

Hab. On the rocky sides of mountain streams. Knock-mel-down mountains, Tipperary.

3. *B. elongatum* (Dicks.). Crypt. Fasc. 2, p. 8. Bryol. Brit., p. 223, tab. 30. Webera elongata, De Notr., Briol. Ital., p. 426. Rabenhor., Bryothec. Europ., No. 275. Pohlia elongata, Hedw., St. Crypt. 1, tab. 36.

Hab. In the rocky cavities of mountain streams. Brandon, Kerry, and near Tralee; Galtee-more, Tipperary.

4. *B. crudum* (Schreb.). Flor. Lips., p. 83. Bryol. Europ., vol. IV. Monogr., p. 37, tab. 348. Bryol. Brit., p. 224, tab. 27. Hook. and Taylor, Muscol. Brit., p. 198. Webera cruda, De Notr., Briol. Ital., p. 424. Rabenhor., Bryothec. Europ., No. 1024.

Hab. Banks and rocks in the more mountainous parts of the country. By the side of the stream leading from Kelly's Glen to Lough Bray, Dublin; near Seven Churches, Wicklow; Brandon, Kerry.

5. *B. nutans* (Schreb.). Spic. Flor. Lips., p. 81. Bryol, Europ., vol. IV. Monogr., p. 34, tab. 347. Bryol. Brit., p. 225, tab. 29. Hook. and Tayl., Muscol. Brit., p. 203. Webera nutans, De Notr., Briol. Ital., p. 427. Rabenbor., Bryothec. Europ., No. 329.

Hab. Heaths and sandy banks in upland parts of the country. A very common species in many parts of Ireland.

6. *B. annotinum* (Hedw.). Sp. Musc., tab. 43. Bryol. Europ., vol. IV. Monogr., p. 40, tab. 352. Bryol. Brit., p. 226, tab. 47. Webera annotina, De Notr., Briol. Ital., p. 421. Rabenhor., Bryothec. Europ., No. 86.

Hab. Banks and sand hills. Portmarnock sands, and on other sandhills round the coast, but very rare in fruit. The only Irish fruited specimen I have seen was collected near the Seven Churches, Wicklow, in 1865. A stone wall has since been built on the spot.

7. *B. carneum* (Linn.). Sp. Pl., p. 1587. Bryol. Europ., vol. IV. Monogr., p. 43, tab. 353. Bryol. Brit., p. 227, tab. 29. Webera carnea, De Notr., Briol. Ital., p. 422. Rabenhor., Bryothec. Europ., No. 236.

Hab. Shady moist banks. In many parts through Ireland this pretty little species may be seen in fruit during the spring months.

8. *B. Wahlenbergii* (Schwaegr.). Suppl., tab. 70. Bryol. Europ., vol. IV. Monogr., p. 44, tab. 354. Bryol. Brit., p. 227, tab. 47. Webera albicans, De Notr., Briol. Ital., p. 420. Rabenhor., Bryothec. Europ., No. 361.

Hab. Wet banks on sides of streams, &c. Abundant and very fine on Connor Hill, Kerry; Kelly's Glen, Dublin; Lough Bray, and Seven Churches, Wicklow; "The Glens," near Cushendall, Antrim.

9. *B. Warneum* (Blandow). Bryol. Univ. 1, 675. Bryol. Europ., vol. IV. Monogr., p. 20, tab. 310. Bryol. Brit., Addenda, p. xii., tab. 12. Rabenhor., Bryothec. Europ., No. 623. Pohlia Warenensis, Schwaegr., Suppl., tab. 236.

Hab. Sand hills near the sea. North Bull, near Dublin. D. Orr, 1860. Portmarnock and Malahide sand hills. Apparently very local in Ireland.

10. *B. pseudotriquetrum* (Schwaegr.). Suppl. 1, 2, p. 110. Bryol. Europ., vol. IV. Monogr.. p. 54, tab. 364. Briol. Brit., p. 230, tab. 30. Rabenhor., Bryothec. Europ., No. 95.

Hab. On wet banks and rocks. Near Belfast; D. Orr. Wet rocks between the Wooden Bridge and Arklow; Benbulben, Sligo; near Clonmel, Tipperary.

11. *B. alpinum* (Linn.). Syst. Pl., p. 949. Eng. Bot., tab. 1263. Bryol. Brit., p. 231, tab. 28. Hook. and Taylor, Muscol. Brit., p. 205. Rabenhor., Bryothec. Europ., No. 94.

Hab. Damp rocks in upland parts of the country. This beautiful species may be known readily by its dusky deep brown foliage, which is a great ornament to the rocks, on which it grows, in many parts of Ireland. Fair Head, Antrim, very fine in fruit, 1837.

12. *B. pallens* (Swartz.). Musc. Suec., tab. 4. Bryol. Europ., vol. IV. Monogr., p. 68, tab. 373. Bryol. Brit., p. 233, tab. 29. Rabenhor., Bryothec. Europ., No. 89. Bryum turbinatum, Hook. and Tayl. (partly), Muscol. Brit., p. 202.

Hab. In glens among the mountains, and in moist places. Kelly's Glen, Dublin. Frequent in County Wicklow, and most other hilly parts of Ireland.

13. *B. Duvalii* (Voit.) Bridel., Bryol. Univ. 1, p. 679. Bryol. Europ., vol. IV. Monogr., p. 64, tab. 371. Rabenhor., Bryothec. Europ., No. 835.

Hab. Marshes and watery places. Near Waterford, Major Madden.

14. *B. uliginosum* (Br. et Sch.). Bryol. Europ., vol. IV., Monogr., p. 18, tab. 339. Bryol. Brit., p. 234, tab. 48. Rabenhor., Bryothec. Europ., No. 931.

Hab. Marshy ground. Dublin mountains; D. Orr. Bog near Cahir, County Tipperary, Isaac Carroll. Very rare in Ireland.

15. *B. pallescens* (Schwaegr.). Suppl., tab. 75. Bryol. Brit., p. 234, tab. 48. Rabenhor., Bryothec. Europ., No. 241.

Hab. Rocks and walls in mountainous parts. Near Clonmel, Mr. Sidebotham; Brandon, Kerry; Benbulben, Sligo.

16. *B. pendulum* (Schimp.). Synops. Muscorum, p. 348. Rabenhor., Bryothec. Europ., No. 443. B. cernuum, Bryol. Europ., vol. IV. Monogr., p. 14, tab. 331. Bryol. Brit., p. 235, tab. 47.

Hab. Walls and gravelly waste places. Near Baldoyle, and wall of the Phœnix Park, Dublin; near Clonmel, Tipperary; Cork and Fermoy, Isaac Carroll. Probably not uncommon.

17. *B. inclinatum* (Br. et Schimp.). Bryol. Europ. Monogr., p. 16, tab. 334. Bryol. Brit., p. 236, tab. 49. Rabenhor., Bryothec. Europ., No. 97.

Hab. Tops of walls and waste places. Common near Cork, Isaac Carroll. On walls near Dublin, D. Orr. At Castle Taylor and Cong, Galway. In pots among the plants in Glasnevin Botanic Garden, probably conveyed with peaty soil from the mountains.

18. *B. intermedium* (Bridel). Bryol. Univ. 1, p. 632. Bryol. Europ., vol. IV. Monogr., p. 47, tab. 356. Bryol. Brit., p. 237, tab. 49. Webera intermedia, Schwaegr. Suppl., tab. 75. Rabenhor., Bryothec. Europ., No. 1030.

Hab. Tops of walls, banks, and gravelly places. Sand-hills opposite Malahide, and on walls near Dublin. Cork, Isaac Carroll. Probably common.

19. *B. bimum* (Schreb.). Sp. Flor. Lips., p. 83. Bryol. Europ., vol. IV. Monogr., p. 56, tab. 363. Bryol. Brit., p. 238, tab. 49. B. ventricosum, Dicks. Pl. Crypt. Fasc. 1, p. 4. Hook. and Taylor, Muscol. Brit., Ed. 2, p. 205.

Hab. Wet, marshy, and boggy places. This fine large species is common in Ireland, and it sometimes appears so like B. pseudotriquetrum, that it is only by the inflorescence it can be satisfactorily distinguished.

20. *B. torquescens* (Br. et Schimp.). Bryol. Europ., vol. IV. Monogr., p. 49, tab. 358. Bryol. Brit., p. 239, tab. 49. Rabenhor., Bryothec. Europ., No. 331.

Hab. On walls and rocks. On the top of a wall near the entrance gate to Sheep-hill Demesne, D. Orr; also at Ashtown, Dublin; near Cong, Galway. This handsome and very distinct species is rare in Ireland, although plentiful in the above localities, where it ripens fruit freely.

21. *B. capillare* (Hedw.). Sp. Musc., p. 131. Bryol. Europ., vol. IV. Monogr., p. 60, tab. 369. Bryol. Brit., p. 242, tab. 29. Engl. Bot., tab. 2007. Hook. and Taylor, Muscol. Brit., p. 200.

Hab. Walls and rocks. This is one of the commonest mosses in Ireland, varying considerably in appearance, according to the nature of the places where it grows. The variety *β. majus* of Bryol. Europ. is the common form in Ireland.

22. *B. Donianum* (Greville), in Linn. Soc. Transact., vol. XV., p. 345, tab. 3, f. 6. Bryol. Brit., p. 211, tab. 49. De Notr., Briol. Ital., p. 391. Schimp. Synops. Muscor., p. 373. B. platyloma, Bryol. Europ., vol. IV. Monogr., tab. 58, p. 366.

Hab. Sandy banks. By the River Lee, above the county gaol, Cork, Isaac Carroll. The male plant only of this species has yet been collected in Ireland.

23. *B. cæspititium* (Linn.) Sp. Pl., p. 1586. Bryol. Europ., vol. IV. Monogr., p. 70, tab. 375. Bryol. Brit., p. 243, tab. 29. Turner, Flor. Hib., p. 120. Engl. Bot., tab. 1904. Hook. and Tayl., Muscol. Brit., p. 291.

Hab. Walls, rocks, and waste ground. Everywhere abundant throughout Ireland; but frequently associated with similar kinds, from which it is distinguished chiefly by the larger mouth of the capsule and dioicous inflorescence.

24. *B. erythrocarpum* (Schwaegr.). Suppl., tab. 70. Bryol. Europ., vol. IV. Monogr., p. 72, tab. 376. De Notr., Briol. Ital., p. 398. Rabenhor., Bryothec. Europ., No. 244. B. sanguineum, Bridel, Bryol. Univ., 1, p. 971. Bryol. Brit., 243, tab. 50.

Var. *β. murorum*, Schimp., Synops., p. 363. Bryum murale (Wils.), Hobkirk, Synopsis of the British Mosses, p. 118 (1873).

Hab. Heaths and dry banks. Frequent in Ireland. On the hill of Howth, where this plant grows in profusion, several plants were once found bearing two capsules on the same pedicel, a very unusual monstrosity among mosses. Var. *β.* near Killarney, G. E. Hunt.

25. *B. atropurpureum* (Web. et Mohr), Ind. Musc.—Bryol. Europ., vol. IV. Monogr., p. 73, tab. 378. Bryol. Brit., p. 244, tab. 50. B. bicolor, Turner, Musc. Hib. (partly). Rabenhor., Bryothec. Europ., No. 87.

Hab. Banks and waste places. On the hill of Howth. Very fine near Seven Churches, Wicklow; Cork, Isaac Carroll; and many other places in Ireland. The dark purple colour, which this pretty little species often assumes, leads to its detection, where otherwise it would be passed over.

26. *B. julaceum* (Smith). Fl. Brit., p. 1357. Engl. Bot., tab. 2270. Bryol. Europ., vol. IV. Monogr., p. 79, tab. 382. Bryol. Brit., p. 246, tab. 28. Hook. and Taylor, Muscol. Brit., p. 197. Rabenhor., Bryothec. Europ., No. 243. Webera julacea, De Notr., Briol. Ital., p. 416.

Hab. Marshy places by the sides of streams and on wet rocks. Frequent about Cromagloun and other places near Killarney; Maam Turc, and elsewhere in Connemara; Cahir Reeks, Tipperary. Isaac Carroll. Lough-Bray and Powerscourt Waterfall, Wicklow. Rarer in the northern counties. A variety with the nerve of the leaf excurrent, forming a short reflexed point, was found near Kenmare by the late Dr. Taylor.

27. *B. argenteum* (Linn.). Sp. Pl., p. 1586. Turner, Fl. Hib., p. 122. Engl. Bot., tab. 1602. Hook. and Tayl., Muscol. Brit., p. 199. Bryol. Brit., p. 247, tab. 29.

Hab. Banks and hardened ground. Frequent everywhere through Ireland, often forming a silvery-looking carpet over the places where it grows.

28. *B. Zierii* (Dicks.). Crypt. Fasc. 1, tab. 4, Fig. 10. Bryol. Europ., vol. IV. Monogr., p. 29, tab. 341. Bryol. Brit., p. 247, tab. 29. Engl. Bot., tab. 1021. Hook. and Tayl., Muscol. Brit., p. 199. Zieria julacea, De Notr., Briol. Ital., p. 432.

Hab. On the highest mountains. Brandon, and also on Macgillicuddy's Reeks, Kerry; Clonty-gearagh, near Cushendun, Antrim.

29. *B. Tozeri* (Greville). Scot. Crypt. Fl., tab. 285. Bryol. Europ., vol. IV. Monogr., p. 41, tab. 353. Bryol. Brit., p. 244, tab. 50. Webera Tozeri, Briol. Ital., p. 423. Rabenhor., Bryothec. Europ., No. 581.

Hab. Shady banks of rivers and rivulets. Side of the River Lee. near the Queen's College, Cork. T. Alexander, 1840. At same place, 1864.

30. *B. roseum* (Schreb.). Spic. Fl. Lips., p. 84. Bryol. Europ., vol. IV. Monogr., p. 56, tab. 365. Bryol. Brit., p. 250, tab. 29. Mnium roseum, Hedwig. Sp., Musc., p. 194.

Hab. Woods and thickets. Near Blarney, Cork, in fruit, T. Drummond. Castle Taylor, Galway; and other parts of Ireland, but nowhere in fruit, save in the locality mentioned. A variety found by the late Dr. Taylor, near Blackwater, Kerry, has the leaves piliferous.

49. AULACOMNION. Schwaegr.

Calyptra cuculliform. Capsule long-pedicellated, oblong, cernuous, ribbed, neck short; lid obtusely rostellate. Peristome double, exterior teeth 16, broad, pugioniform-subulate, hygroscopic, trabeculated internally; inner peristome membranous, cut into 16 processes, with ciliolæ interposed 2–3 together. Leaves oval or linear-lanceolate, costate nearly to the apex; areolation small, granular and dot-like. Differing from Bryum more in habit than by any real characters.

1. *A. palustre* (Schwaegr.). Suppl., tab. 226. Bryol. Europ., vol. IV. Monogr., p. 9, tab. 405. Bryol. Brit., p. 216, tab. 27. Rabenhor., Bryothec. Europ., No. 101. Mnium palustre, Hedw., Sp. Musc., p. 188. Bryum palustre, Engl. Bot., tab. 391. Muscol. Brit., p. 193.

Hab. Wet heaths and marshy places. Of frequent occurrence in most parts of Ireland.

50. Leptobryum. Wilson.

Peristome as in Bryum. Capsule exactly pyriform, pendulous. Leaves acuminate-setaceous. Plant annual. Differing slightly from Bryum in its mode of growth; the annual stems not producing innovations from the apex.

1. *Leptobryum pyriforme* (Wilson). Bryol. Brit., p. 219, tab. 27. Schimp., Synops. Muscor., p. 329. De Notr., Briol. Ital., p. 434. Bryum pyriforme, Rabenhor., Bryothec. Europ., No. 93. Schwartz, Musc. Suec.—Hook. and Tayl., Muscol. Brit., p. 196.

Hab. Shady damp banks and rocks. By the side of the River Boyne, about two miles above Drogheda. Caves at Blarney, Cork, Isaac Carroll. Near the Spa, Clonmel, Miss A. Taylor; but rare in Ireland. It grows in great abundance on the mould of flower-pots in the Botanic Garden, Glasnevin, both in houses, where the heat is seldom under 65 degrees Fahrenheit, and in cool frames and conservatories.

51. Mnium. Linn.

Calyptra small, cuculliform, conically attenuated, split at the side, fugacious. Capsule long-pedicellated, oval, or oblong, annulate, mostly pendulous. Peristome double; outer teeth 16, lanceolate-cuspidate, trabeculated on the inner surface; inner peristome membranous, cut into 16 processes, coroniform, plicated and perforated or lacunose in the middle; intermediate appendiculate ciliolæ present. Leaves mostly large, smooth, and glossy, with spinulose or thickened borders, and percurrent costæ; areolation large, of roundish-hexagonal cellules. Inflorescence synoicous or dioicous. Male flowers discoid.

Diagnosis of Species.

Inflorescence Dioicous.

Stems erect from a creeping rhizome; leaves broad, ovate-ligulate, their margin thickened, dentate-serrate; capsule oblong-pendulous; fruit stalks aggregated, . 1. M. undulatum.

Stems radiculose, erect; sterile shoots procumbent; leaves of fertile stem ovate-lanceolate, decurrent; upper leaves elliptic-oblong, apiculate, bordered, serrated; fruit stalks aggregated, . . . 2. M. AFFINE.

Leaves obovate-rotundate, narrowed at base, margined, entire; capsule oblong-pendulous, ... 3. M. PUNCTATUM.

Stems elongated on the erect barren shoots; leaves lanceolate-acute, border cartilaginous, denticulated, nerve scarcely percurrent; capsule oblong-pendulous; lid mucronulate, ... 4. M. HORNUM.

Inflorescence Synoicous.

Fertile stems erect, sterile shoots procumbent; leaves elliptic, obovate, decurrent at base, cuspidate, serrated; capsule ovate, subpendulous, . . . 5. M. CUSPIDATUM.

Fertile stems decumbent at base; barren shoots spreading or decumbent; leaves ovate-oblong, obtuse, bordered, bluntly dentated; capsule oval, subpendulous; lid apiculate, ... 6. M. ROSTRATUM.

Leaves ovate acute; perichætial leaves lanceolate, all doubly serrated and margined, nerve excurrent; capsule oblong-pendulous, ... 7. M. SERRATUM.

1. *M. undulatum* (Hedw.). Sp. Musc., p. 195. Bryol. Europ., vol. IV. Monogr., pp. 20, 21, tab. 389. Bryol. Brit., p. 256, tab. 30. Bryum ligulatum, Engl. Bot., tab. 1449. Muscol. Brit., p. 207.

Hab. Woods and damp shady banks. Not unfrequent in Ireland, but rarely fruiting.

2. *M. affine* (Blandow). Musc. Exsic.—Bryol. Europ., vol. IV. Monogr., p. 30, tab. 397–399. Bryol. Brit., p. 253, tab. 51, Rabenhor., Bryothec. Europ., No. 328. Bryum affine, Hook., in Engl. Fl., vol. v. Wilson, in Engl. Bot. Suppl., tab. 2739.

Hab. Woods, banks, and sand-hills. Abundant on sand-hills near Dunfanaghy, Donegal, 1868. Woods at Castle Taylor, Galway, 1869.

3. *M. punctatum* (Hedw.). Sp. Musc., p. 193. Bryol. Europ., vol. IV. Monogr., p. 19, tab. 387. Bryol. Brit., p. 258, tab. 30. Bryum punctatum, Engl. Bot., tab. 1183. Hook. and Tayl., Muscol. Brit., p. 207.

Hab. Watery places, and by sides of rivulets, &c. One of the commonest species of the genus, and generally distributed through Ireland.

4. *M. hornum* (Linn.). Sp. Pl., p. 1576. Bryol. Europ., vol. IV. Monogr., p. 22, tab. 390. Bryol. Brit., p. 256, tab. 31. Bryum hornum, Turner, Fl. Hib., p. 128. Engl. Bot., tab. 2271. Muscol. Brit., p. 209.

Hab. Woods and shady banks, about roots of trees, &c. Very common in such places through Ireland.

5. *M. cuspidatum* (Hedw.). Sp. Musc., tab. 48, figs. 5, 6, 7. Bryol. Europ., vol. IV. Monogr., p. 29, tab. 396. Bryol. Brit., p. 254, tab. 31. Bryum cuspidatum, Engl. Bot., tab. 1474. Muscol. Brit., p. 209.

Hab. Moist shady rocks and banks. Near Killarney; Castle Taylor, Galway. Rather rare in Ireland.

6. *M. rostratum* (Schwaegr.). Suppl., tab. 79. Bryol. Europ., vol. IV. Monogr., p. 27, tab. 395. Bryol. Brit., p. 254, tab. 31. Bryum cuspidatum, Turner, Musc. Hib., p. 131. Engl. Bot., tab. 1474. Muscol. Brit., p. 209.

Hab. Moist shady rocks. Dargle River, Wicklow. Not uncommon on banks of rivers in Ireland. Taylor, in Fl. Hib.

7. *M. serratum* (Bridel). Bryol. Univ. 1, p. 689. Bryol. Europ., vol. IV. Monogr., p. 24, tab. 391. Bryol. Brit., p. 255, tab. 31. Bryum serratum, Bridel, Mant.—Bryum marginatum. Dickson. Pl. Crypt. Fasc. 2, tab. 5, f. 1. Musc. Hib., p. 129. Hook. and Tayl., Muscol. Brit., Ed. 2, p. 208.

Hab. Shady banks among rocks, particularly in limestone districts. Benbulben, Sligo; Dargle river, Wicklow. Rare in Ireland.

Obs. The genus Meesia seems to be wanting in Ireland, though admitted by Wilson in his "Bryologia Britannica" on faith of a single (probably foreign) specimen of Meesia longiseta, found in Turner's "Herbarium," mixed with specimens of Amblyodon dealbatus, which were sent to Turner by Dr. Scott, as having been collected on the borders of a lake in the north of Ireland. Musc. Hib. Spic., p. 116, and Muscol. Brit, p. 195.

52. AMBLYODON. P. Beauvois.

Calyptra inflated at the base, constricted at the mouth, split at the side, fugacious. Capsule oblong-pyriform, sub-cernuous. Peristome double; outer teeth 16, shorter than the inner peristome, which consists of 16 long carinate processes, without intermediate ciliolæ. Leaves spreading, of a broadly lanceolate form; nerve not reaching quite to the apex; areolation large, loose, of a rhomboidal form. Inflorescence monoicous or polygamous.

1. *A. dealbatus* (P. Beauv.). Prodr., p. 41. Schimp., Synops. Muscor., p. 403. Bryol. Brit., p. 267, tab. 28. Rabenhor., Bryothec. Europ., No. 99. Meesia dealbata, Hedw., Sp. Musc., p. 4, tab. 41. Bryum dealbatum, Dickson, Pl. Crypt. Fasc. 2, tab. 5, f. 3. Musc. Brit., Ed. 2, p. 196.

Hab. Wet marshy moors, and low ground among the sand-hills on the coast. North of Ireland (Templeton). Fl. Hib. On a flow bog in the parish of Rasharkin, Antrim, 1837. Abundant in hollows among the sand-hills between Malahide and Portrane.

Tribe 11. HOOKERIEÆ.

53. DALTONIA. Hook. et Tayl.

Calyptra conico-mitriform, ciliated at the base. Capsule pedicellated, erect, oval, or oval-oblong, slightly swollen at the neck, without annulus; lid rostrate, beak straight. Peristome double, exterior teeth 16, spreading, trabeculated, and marked with a medial line; inner peristome membranous, divided nearly to the base into 16 cilia, as long as the outer teeth. Leaves spreading almost regularly round the stem, lanceolate or linear-lanceolate, with a thickened entire border; areolation rather close, formed of rhomboidal cellules.

1. *D. splachnoides* (Hook. and Tayl.). Muscol. Brit., p. 139. Bridel. Briol. Univ. 2, p. 255. Bryol. Brit., p. 418, tab. 22. Rabenhor., Bryothec. Europ., No. 579. Neckera splachnoides, Smith, Engl. Bot., tab. 2564. Hookeria spalachnoides, Taylor, in Fl. Hib., p. 36.

Hab. Moist shady rocks and banks, rarely on trees. Seeghane mountain, near Dublin, Dr. Taylor; Torc waterfall; Cromagloun; and Purple Mountain, Killarney; Brandon mountain; also on the mountains between Tralee and Dingle, Kerry.

54. Hookeria. Smith.

Calyptra large, mitriform, conoidly-attenuated, constricted at first at the base, afterwards lobed. Capsule on a long, thickish pedicel, ovate, symmetrical, nutant or horizontal; lid conic-rostrate. Peristome double, the exterior of 16 linear-lanceolate teeth, closely articulated; inner a membrane cut into 16 cilia, without internal ciliolæ. Leaves complanate, spreading laterally, ovate or ovate-lanceolate; areolation large, loose, formed of hyaline, ovate, hexagonal, cellules. Inflorescence usually monoicous.

Diagnosis of Species.

Stem procumbent, compressed; leaves bifarious, obovate, obtuse, entire, nerveless, ... 1. H. lucens.

Stems procumbent subpinnate; leaves bifarious, acuminulate, marginate, doubly nerved half way, serrulate at apex, . 2. H. lætevirens.

1. *H. lucens* (Dill.). Dill., Musc., tab. 34, f. 10. Engl. Bot., tab. 1902. Bryol. Brit., p. 416, tab. 27. Pterygophyllum lucens, Bridel, Bryol. Univ. 2, p. 343. De Notr., Briol. Ital., p. 62. Rabenhor., Bryothec. Europ., No. 2.

Hab. Damp shady banks, and by the sides of rivulets. Frequent and generally distributed through Ireland, particularly in the more hilly parts of the country.

2. *H. lætevirens* (Hook. et Taylor). Muscol. Brit., p. 149. Bryol Brit., p. 417, tab. 27. Hookeria albicans, Tayl. in Fl. Hib., p. 36. Rabenhor., Bryothec. Europ., No. 586. Pterygophyllum lætevirens, Bridel, Bryol. Univ. 2, p. 350.

Hab. Shady wet rocks, and sides of streams. First found by Mr. James Drummond, at Dunscombe's Wood, near Cork; at O'Sullivan's Cascade, and Torc Waterfall, Killarney, W. H. Harvey, where I have since collected it, in company with Dr. Schimper and Mr. Wilson, in June, 1866. Glendine Wood, Waterford, Thomas Wright, *fide* Isaac Carroll.

Tribe 12. NECKEREÆ.

Sub-Tribe *Cryphæeæ.*

Sect. 1. Peristome wanting.

55. HEDWIGIA. Ehrh.

Calyptra small, conical, smooth, or hairy. Capsule globose, erect, shortly pedicellate or immersed; annulus none; lid disciform, obtuse, or papillate. Peristome wanting. Leaves spreading, ovate-lanceolate, papillose, nerveless, diaphanous at the apex, erose-denticulate or fringed at the margin; areolation small, quadrate, basal cellules, elongated and subflexuose. Inflorescence monoicous; male flowers axillary, gemmiform.

1. *H. ciliata* (Hedw.). St. Crypt. 1, tab. 40. Bryol. Europ., vol. III. Monogr., p. 5, tab. 272–273. Schimp., Synops. Muscor., p. 238. Bryol. Brit., p. 146, tab. 6. Rabenhor., Bryothec. Europ., No. 514. Anictangium ciliatum, Turner, Muscol. Hib. p. 11. Hook. and Tayl., Muscol. Brit., p. 217.

Hab. On exposed rocks. This very common moss is generally distributed through Ireland, and occurs from the sea level to a great elevation on the mountains. It varies considerably in appearance and size. The varieties γ *viridis* of Wilson's "Bryologia Britannica," and δ. *secunda* grow at Lough Bray and Luggielaw, Wicklow. Though usually arranged with gymnostomous mosses, this genus, and the following, are in habit and structure more nearly allied to the present group.

56. HEDWIGIDIUM. Br. et Schimp.

Scarcely distinguishable from Hedwigia. The leading characters employed by Bruch and Schimper for separating it are the irregularly branched stoloniferous stem, sending out descending flagellæ from the sides and extremities of the branches; leaves longitudinally plicate; areolæ more elongated, barren flowers, terminal capsule more or less exserted; calyptra more or less cucullate. (Wilson in Bryol. Brit., p. 147).

1. *H. imberbe* (Br. et. Schimp.). Bryol. Europ., vol. III. Monogr., p. 3, tab. 274. Bryol. Brit., p. 148, tab. 6. Rabenhor., Bryothec. Europ., No. 921. Anictangium imberbe, Hook. and Tayl. Muscol. Brit., p. 27.

Hab. On the faces of moist rocks. Near Bantry, Miss Hutchins; and near Glengarriff, Cork, Wilson; Fair-Head, Antrim, very fine, May, 1854; Brandon, Kerry; Lugnaquillia, Wicklow.

Sect. 2. Peristome single.

57. Leucodon. Schwaegr.

Calyptra dimidiate-large. Capsule ovate, thick; its pedicel enclosed by the perichætial leaves. Peristome single, of 16 equidistant entire or perforated teeth, and with a medial line, sometimes slightly bifid at the apex. Leaves ovate-acute, imbricated, entire, reflexed at the margin, and nerveless. Inflorescence dioicous.

1. *L. sciuroides* (Schwaegr.). Suppl., tab. 125, fig. 10. Schimp., Synops. Muscor., 475. Bryol. Brit., p. 313, tab. 20. Muscol. Brit., Ed. 2, p. 112. Rabenhor., Bryothec. Europ., No. 137.

Hab. Trunks of trees. Near the Longford Bridge, Royal Canal, D. Orr. Abundant on trees about Beauparc, Meath, and at Bantry, Cork. Singularly rare in Ireland, and very seldom fruiting.

Sect. 3. Peristome double.

57A. Antitrichia. Bridel.

Calyptra cuculliform, rather large. Capsule pedicellate, pedicel scarcely longer than perichætial leaves; oval, exannulate; lid conoid, bluntly-rostrate. Peristome double, the exterior of 16 elongate-lanceolate teeth; interior of 16 narrow filiform fugacious cilia, alternating with the outer teeth, obscurely united at the base. Leaves ovate-lanceolate, denticulate, shortly costate; areolation rather dense.

1. *A. curtipendula* (Bridel). Br., Univ. 2, p. 222. Schimp., Synops. Muscor., p. 476. Bryol. Brit., p. 316, tab. 22. Rabenhor., Bryothec. Europ., No. 289. Neckera curtipendula, Turner, Musc. Hib., p. 102. Engl. Bot., tab. 1444. Anomodon curtipendulum, Hook. and Taylor, Muscol. Brit., Ed. 2, p. 137.

Hab. On rocks and trees, chiefly in mountainous districts. Fruiting at Lough Bray. Very fine and large on Brandon Mountain, Kerry. Though not very common, it occurs in most of the counties of Ireland.

58. CRYPHÆA. Bridel.]

Calyptra conico-mitriform, small, lacerated at the base. Capsule immersed, oval-oblong, annulate; lid rostrate, beak straight. Peristome double, the exterior of 16 teeth, remotely articulated; the interior divided nearly to the base into 16 carinate cilia, alternating with the outer teeth. Leaves imbricated, adpressed when dry, nerved half way or nearly to the apex; areolation dense, roundish, or dot-like. Inflorescence monoicous.

1. *C. heteromalla* (Bridel). Bryol. Univ. 2, p. 250. Schimp., Synop. Muscor., 463. Bryol. Brit., p. 420, tab. 22. Rabenhor., Bryothec. Europ., No. 684. Neckera heteromalla, Engl. Bot., tab. 1180. Daltonia heteromalla, Hook. and Tayl., Muscol. Brit., Ed. 2, p. 139.

Hab. Trunks of trees and bushes. Abundant in Dublin and Wicklow; also in the southern and western counties, but rarer in the north.

Sub-Tribe. METEORIEÆ.

59. FONTINALIS. Dillenius.

Calyptra conic, slightly lacerate at base, apex slender, subulate. Capsule ovate, symmetrical, immersed among the perichætial leaves; lid conical. Peristome double, the exterior of 16 linear-lanceolate teeth, distinct or cohering in pairs at their apices, the interior of 16 filiform cilia, slightly flexuose, and connected by cross-bars into a plicated cone. Leaves three-ranked, nerveless; areolation small, composed of narrow rhomboidal cells, of nearly equal size in all parts of the leaf. Large water mosses.

Diagnosis of Species.

Stems irregularly-branched; leaves disposed triquetrously, broadly ovate or ovate-lanceolate, plicato-carinate, . . . 1. F. ANTIPYRETICA.
Stems slender, branches fasciculate; leaves oblongo-lanceolate, concave; perichætial leaves apiculate, ... 2 F. SQUAMOSA.

1. *F. antipyretica* (Linn). Sp. Plant., p. 1571. Bryol. Europ., vol. v. Monogr., p. 5, tab. 439. Bryol. Brit., p. 423, tab. 22. Turner, Musc. Hib., p. 199. Engl. Bot., tab. 359. Muscol. Brit., Ed. 2, p. 140.

Hab. In rivulets, lakes, and stagnant water. Very general through Ireland, adhering to stones and wood in the water. Stems sometimes 12 inches long at Killarney.

2. *F. squamosa* (Linn.). Sp. Pl. 1591. Bryol. Europ., vol. v. Monogr., p. 6, tab. 430. Bryol. Brit., p. 424, tab. 22.

Hab. Lakes and rivulets in upland parts of the country. Luggielaw and Lough Bray, Wicklow; O'Sullivan's Cascade, Killarney; Connemara; and also in Co. Cork. Not so common as the former.

Sub-Tribe. EUNECKEREÆ.

60. NECKERA. Hedw.

Calyptra cuculliform, short, smooth. Capsules shortly pedunculated, sometimes immersed among the perichætial leaves; lid conico-rostellate. Peristome double, the exterior of 16 linear acuminated teeth, scarcely trabeculated; the interior of 16 narrow cilia, usually shorter than the exterior teeth. Leaves imbricated, complanate, somewhat four-ranked, scimitar-shaped, or ovate-lanceolate, very shortly costate or ecostate, undulated transversely and of a smooth shining texture; areolation rhomboidal and rather dense. Inflorescence monoicous or dioicous.

Diagnosis of Species.

Inflorescence dioicous.

Stems pinnate; leaves bifarious, oblong, acuminulate, transversely wrinkled, . 1. N. CRISPA.

Stems subpinnate; leaves broad, ovate-acuminate, serrulate, margin recurved two nerved at the base, . . . 2. N. PUMILA.

Inflorescence monoicous.

Stems pinnate, branches complanate; leaves subfalciform, nerveless, entire; capsule oblong, immersed in the perichætial leaves, ... 3. N. PENNATA.

1. *N. crispa* (Dill). Musc., tab. 36, f. 12. Bryol. Europ., vol. v. Monogr., p. 9, tab. 443. Bryol. Brit., p. 412, tab. 22. Turner, Musc. Hib., p. 101. Hook. and Taylor, Muscol. Brit., p. 136. Rabenhor., Bryothec. Europ., No. 143.

Hab. Shady rocks, glens and woods in hilly parts of the country; also on trunks of trees. This fine moss covers the faces of rocks in masses several yards in diameter, and sometimes the whole trunks of trees, as at Cromagloun. It is only in warm sheltered situations that it bears fruit freely.

2. *N. pumila* (Hudson). Fl. Angl., p. 468. Bryol. Europ., vol. v. Monogr., p. 8, tab. 442. Bryol. Brit., p. 413, tab. 22. Rabenhor., Bryothec. Europ., No. 748.

Hab. On trunks of trees and on bushes. Westaston and Powerscourt, Wicklow. Not very common but of rather frequent occurrence in the eastern and southern counties. It has not been found fruiting in Ireland.

3. *N. pennata* (Linn.). Sp., Plant., p. 1571. Bryol. Europ., vol. v. Monogr., p. 6, tab. 44. Bryol. Brit., p. 414, tab. 34.

Hab. Trunks of trees. Colin Glen, near Belfast, D. Orr. Not hitherto seen growing in Ireland by any other person.

61. HOMALIA. Schimp.

Calyptra cuculliform, short and fugacious. Capsule long-pedicellated, erect or slightly cernuous. Peristome double, the exterior of 16 longish subulate trabeculated teeth; the interior of 16 cilia, as long as the exterior teeth, intermediate ciliolæ single, short, or none. Leaves complanate, ovate-oblong, obtuse, apiculate, nerveless, or faintly nerved at the base; areolation rather dense, cellules of an elongated rhomboidal form. Inflorescence monoicous or dioicous.

Diagnosis of Species.

Stem pinnate, branches attenuated; leaves ovate-oblong, obtuse, apiculate, faintly two-nerved at the base; capsule roundish, elliptical; lid apiculate. Inflorescence dioicous, ... 1. H. COMPLANATA.

Stem irregularly pinnate; leaves subsecund, falciform, obtuse, serrulate at the apex. Inflorescence monoicous, . . . 2. H. TRICHOMANOIDES.

1. *H. complanata* (Linn.) Sp. Pl., p. 1588. Briol. Ital., p. 199. Neckera complanata, Bryol. Europ., vol. v. Monogr., p. 3, tab. 444. Bryol. Brit., p. 411, tab. 24. Hypnum complanatum, Turner, Musc. Hib., p. 144. Hook. and Taylor, Muscol. Brit., p. 152.

Hab. Trunks of trees, walls, and rocks. Frequent in many parts of Ireland, and generally distributed.

2. *H. trichomanoides* (Dill.). Musc., tab. 34, f. 7. Bryol. Europ., vol. v. Monogr., p. 3, tab. 446. Rabenhor., Bryothec. Europ., No. 71. Omalia trichomanoides, Bryol. Brit., p. 410, tab. 24. Hypnum trichomanoides, Turner, Musc. Hib., p. 145. Hook. and Tayl., Muscol. Brit., p. 152.

Hab. Trunks of trees, hedges, bushes, and rocks. Very common in every part of Ireland.

Tribe 13. STEREODONTEÆ.

62. PLAGIOTHECIUM. Bryol. Europ.

Capsule leptodermous, oblong or roundish, generally cernuous or inclined to horizontal; lid large, conico-convex, with a long or short beak; annulus composed of single, double, or treble series of cells. Peristome double; outer of 16-teeth; interior peristome of 16 carinate cilia; entire or approaching in pairs between the spaces of the outer teeth; rudimentary ciliolæ at base sometimes present. Leaves five-ranked, complanately distichous, sometimes secund, nerveless, or shortly two-nerved at the base, soft and flaccid, or firm; areolation rather large, composed of rhomboidal hexagonal cellules, the basal cells longer, more transparent and flexuose.

This group is intermediate between the Neckereæ and Hypneæ, agreeing with the former in habit of stems and leaves, with the latter in fruit.

Diagnosis of Species.

Inflorescence dioicous.

Stem procumbent, with subfasciculate branches; leaves ovate, acute, transversely undulated, with two short nerves at base; capsule cernuous, striated when dry; lid rostellate, . . 1. P. UNDULATUM.

Stem decumbent, with elongated branches; leaves ovate-oblong, acute, subcomplanate, large, entire, two-nerved at base, bright green; capsule oblong-cylindrical; lid with a short beak, ... 2. P. SYLVATICUM.

Stems and branches prostrate, pinnate, occasionally proliferous; leaves spreading, complanate, ovate-lanceolate, slender-pointed, obscurely toothed; nerveless or slightly two-nerved at base; capsule small, pendulous; lid conical-apiculate. Inflorescence dioicous, . . . 3. P. ELEGANS.

Inflorescence monoicous.

Stem prostrate, sparingly branched; leaves ovate or ovate-lanceolate, two-nerved at the base, complanate, pale green; capsule oblong-cylindraceous, nearly erect; lid acutely conical, . . . 4. P. DENTICULATUM.

Stems slightly creeping, with suberect branches; leaves loosely imbricated, the upper subsecund, attenuate-subulate, entire, nerveless; capsule ovate-cylindrical; lid conical, apiculate, . . 5. P. PULCHELLUM.

1. *P. undulatum* (Linn.).—Bryol. Europ., vol. v. Monogr., p. 17, tab. 506. Schimp., Synops. Muscor., p. 586. Hypnum undulatum, Bryol. Brit., p. 405, tab. 24. Turner, Musc. Hib., p. 154. Engl. Bot., tab. 1181. Hook. and Tayl., Muscol. Brit., p. 153.

Hab. Woods and banks. Frequent in most parts of Ireland, but seldom abundant.

2. *P. sylvaticum* (Linn.).—Bryol. Europ., vol. v. Monogr., p. 14, tab. 503. Schimp., Synop. Muscor., p. 585. Rabenhor., Bryothec. Europ., No. 448. Hypnum sylvaticum, Bryol. Brit., p. 406, tab. 24. H. denticulatum var. β sylvaticum, Turner, Musc. Hib., p. 146, tab. 12, f. 1.

Hab. Damp ground in woods, and about the roots of trees. Luggielaw woods, Wicklow; woods at Killarney; but not common in Ireland.

3. *P. elegans* (Hooker). Musc. Exot., tab. 9. P. Schimperi, Milde et Jur. in Rabenhor., Bryothec. Europ., No. 588. Hypnum elegans, Wilson, Bryol. Brit., p. 408, tab. 59.

Hab. Damp shady banks and rocks. Frequent at Killarney, Cromagloun, and other places in Kerry; also at Powerscourt Waterfall, Wicklow; fruiting at Eagle's Nest, Killarney. G. E. Hunt (1872).

4. *P. denticulatum* (Dill.). Bryol. Europ., vol. v. Monogr., p. 12, tab. 501–502. Schimp., Synops. Muscor., p. 582. Rabenhor., Bryothec. Europ., No. 691. Hypnum denticulatum, Bryol. Brit., p. 407, tab. 24. Turner, Musc. Hib., p. 146. Engl. Bot., tab. 1260.

Hab. Woods, banks, and rocks. Frequent in many parts of Ireland. The variety *β. obtusifolium*, Hook. and Tayl., *var. γ*, Turner, Musc. Hib., p. 146, tab. 12, f. 2, was collected on the top of Benbulben, Sligo, by Robert Brown.

5. *P. pulchellum* (Dicks.). Bryol. Europ., vol. v. Monogr., p. 9, tab. 497. Schimp., Synops. Muscor., p. 578. Rabenhor., Bryothec. Europ., No. 16. Hypnum pulchellum, Bryol. Brit., p. 403, tab. 24. Turner, Musc. Hib., p. 136. Hook. and Tayl., Muscol. Brit., p. 163.

Hab. Wet banks among rocks in the mountainous parts of Ireland. Sillagh-braes, near Larne, Antrim; Carrantuohill; and Macgillicuddy's Reeks, Kerry; Powerscourt Waterfall, Taylor, in Fl. Hib.

63. Cylindrothecium. Br. et Schimp.

Calyptra dimidiate, narrow, elongated. Capsule erect cylindrical, pedicellate, annulate; lid conico-rostellate. Peristome double, the exterior of 16 trabeculated teeth, slightly split at the apex; the interior of 16 cilia, narrow and carinate, slightly connected at the base. Leaves imbricated, compressed, very shortly two-nerved, or nerveless, having a shining lustre when dry; areolation rather dense, composed of narrow elongated cellules, larger and more transparent at base.

1. *C. concinnum* (De Notr.). Mantiss. No. 18. Schimp., Synops. Muscor., p. 516. C. Montagnei, Bryol. Europ., vol. v. Monogr., p. 6, tab. 465. Bryol. Brit., p. 327, tab. 54. Rabenhor., Bryothec. Europ., No. 19.

Hab. Banks, rocks, and sand-hills. Portmarnock sands, D. Orr; Glen near Sallygap; sand-hills between Malahide and Portrane, Dublin; Dunfanaghy, Donegal, 1866.

Tribe 14. HYPNEÆ.

Sub-tribe. *Isotheciea.*

64. PTEROGONIUM. Schwartz.

Calyptra cucullate, deeply split at the side. Capsule on an elongated pedicel, oblong, thick; lid rostellate. Peristome double; outer of 16 short, slightly hygrometric teeth; inner cilia 16, short, slender, partially adherent to the outer teeth. Leaves ovate-acuminate, shortly bicostate at base; areolation rather dense, composed of hexagonal cellules. Inflorescence dioicous.

Diagnosis of Species.

Stems with fascicled incurved branches; leaves broadly ovate-acuminate, concave, their margins plane, serrulate near the apex, faintly two-nerved; capsule oblong; lid conical, ...	1. P. GRACILE.
Leaves subsecund, ovate, subacuminate, concave, papillose, serrulate at the apex; capsule elliptic-oblong; lid rostrate, .	2. P. FILIFORME.

1. *P. gracile* (Schwartz.). Musc. Succ., p. 26. Schimp., Synops. Muscor., p. 500. Bryol. Brit., p. 321, tab. 14. Hook. and Taylor, Muscol. Brit., p. 74. Rabenhor., Bryothec. Europ., No. 686.

Hab. Rocks and large stones in hilly parts of the country, especially near the borders of lakes, as at Lough Bray and Luggielaw, Wicklow. This moss occurs in most of the counties of Ireland.

2. *P. filiforme* (Schwaegr.) Suppl. 1, p. 100. Bryol. Brit., p. 320, tab. 14. Hooker and Taylor, Muscol. Brit., p. 75. Pterigynandrum filiforme, Bryol. Europ., vol. v. Monogr., p. 3, tab. 460. Schimp., Synops. Muscor., p. 508. Briol. Ital., p. 219. Rabenhor., Bryothec. Europ., No. 637.

Hab. Dry rocks in shaded woods. Frequent, particularly in the upland districts.

65. ISOTHECIUM. Bridel.

Calyptra cucullate. Capsule ovate, of thick texture, erect, and symmetrical. Peristome double; outer teeth 16, trabeculated, and marked with a medial line; inner peristome of 16 carinate, lanceolate-subulate cilia, with ciliolæ present. In all respects similar to Hypnum, except in the erect symmetrical capsules, and differing from Pterogonium in the more perfect development of the peristome and annulus. (Wilson).

1. *I. myurum* (Dill.). Musc., tab. 41, f. 50. Bryol. Brit., p. 323, tab. 25. Rabenhor., Bryothec. Europ., No. 190. Hypnum curvatum, Turner, Musc. Hib., p. 139. Engl. Bot., tab. 1566. Hooker and Taylor, Muscol. Brit., Ed. 2, p. 169.

Hab. On trees and rocks. Distributed generally through Ireland, and of frequent occurrence.

65.* Climacium. Web. et Mohr.

Calyptra dimidiate, rather long, and slightly twisted. Capsule oval or ovate-cylindrical; lid conico-rostellate, persistent on top of columella. Peristome double; the exterior of 16 closely articulated teeth; inner peristome membranaceous, cut into 16 carinate lacunose processes, which are connected at the base. Leaves spreading every way, ovate, or ovate-cordate, partially plicate, costate; areolation narrow, and rather close.

1. *C. dendroides* (Web. et Mohr.). Iter. Suec., p. 961. Bryol. Brit., p. 426, tab. 25. Bryol. Europ., vol. v. Monogr., p. 5, tab. 437. Rabenhor., Bryothec. Europ., No. 3. Hypnum dendroides, Dill. Musc., tab. 40, f. 48. Engl. Bot., tab. 1565. Hooker and Taylor, Muscol. Brit., Ed. 2, p. 168.

Hab. Boggy and marshy meadows, and on wet ground. This large and handsome species is very abundant in Ireland. By the side of the upper lake at Killarney, the stems grow from four to six inches high. It is not often seen in fruit.

66. Homalothecium. Schimper.

Calyptra cuculliform. Capsule long-pedicelled, smooth or rough; lid conic-rostellate, rather obtuse at apex. Peristome double; exterior of 16-teeth, lanceolate-subulate, slightly trabeculated; interior of 16 filiform short cilia from a plicate base, or a membrane lining the teeth, no intermediate ciliolæ. Leaves shining with a silky lustre, costate; areolation composed of oblong-rhomboidal cellules, larger and more pellucid at base. Inflorescence monoicous or dioicous.

1. *H. sericeum* (Linn.). Bryol. Europ., vol. v. Monogr., p. 3, tab. 456 Schimp., Synops. Muscor., p. 525. De Notr., Briol. Ital. p. 203. Rabenhor., Bryothec. Europ., No. 446. Leskea sericea Dill. Musc., tab. 42, f. 59. Bryol. Brit., p. 333, tab. 25. Hedw., St. Cr., vol. iv., tab. 17. Funck, Deutsch. Moose., tab. 36, f. 12. Hypnum sericeum, Turner, Musc. Hib., p. 138. Engl. Bot., tab. 1445. Hooker and Taylor, Musc. Brit., Ed. 2, p. 165.

Hab. Chiefly on trunks of trees, whose stems and branches are often quite covered with it; also on walls and rocks. Very common.

66*. PYLAISIA. Schimp.

ORTHOTHECIUM. Bryol. Europ.

Stems creeping. Capsule ovate, oblong-elliptic, upright or slightly inclined. Peristome double; the outer of 16 linear-lanceolate sharp-pointed teeth; the inner cilia rising from a short basilar membrane, equalling in length the outer teeth, and interruptedly cleft along their keels, rudimentary irregular ciliolæ sometimes present. Leaves ovate or lanceolate, mostly plicate, and for the most part without a distinct middle nerve; areolation composed of long hyaline cells, larger towards the base. The species under this genus have been placed in different genera. Wilson includes them under Leskea in his "Bryologia Britannica."

Diagnosis of Species.

Leaves imbricated, lanceolate-acuminate, plicate-striate, nerveless, . . .	1. P. RUFESCENS.
Leaves lanceolate, erecto-patent, subsecund, nerveless, entire, slightly striate, .	2. P. SUBRUFA.

1. *P. rufescens* (Schwaegr.). Suppl., tab. 86. Pylaisia rufescens, Rabenhor., Bryothec. Europ., No. 134. Orthothecium rufescens, Bryol. Europ., vol. III. Monogr, p. 3, tab. 460. Leskea rufescens, Bryol. Brit., p. 534, tab. 25, Hypnum rufescens, Engl. Bot., tab. 2296. Hooker and Taylor. Muscol. Brit., p. 164.

Hab. Mountain rocks. Abundant on and about Benbulben, Sligo.

2. *P. subrufa* (Wilson). Leskea subrufa, Bryol. Brit., p. 33, tab. 54. Orthothecium intricatum, Bryol. Europ., vol. v. Monogr., p. 5, tab. 462–463. Isothecium chryseum, Spruce, Ann. Nat. Hist., vol. iii., p. 147.

Hab. Mountain rocks. Benbulben, Sligo, where I collected this rare moss in fruit, very sparingly in July, 1856. Not observed elsewhere in Ireland, so far as I know.

Sub-tribe. *Thuyidieæ.*

67. THAMNIUM. Schimp.

Peristome as in Hypnum, but distinguished chiefly by the habit of the primary stems of the plants, which are rhizomatous at their bases; with flat dendroid branches. Leaves ovate-lanceolate, strongly nerved; areolation rather dense. Capsules aggregated, cernuous, with rostrate lids.

1. *T. alopecurum* (Linn.).—Bryol. Europ., vol. v. Monogr., p. 4, tab. 518. Briol. Ital., p. 64. Rabenhor., Bryothec. Europ., No. 902. Isothecium alopecurum, Bryol. Brit., p. 324, tab. 25. Hypnum alopecurum, Engl. Bot., tab. 1182. Hook. and Taylor. Muscol. Brit., p. 168.

Hab. By the sides of rivulets, and in moist woods. Frequent.

67*. HETEROCLADIUM. Schimp.

Distinguished chiefly by the prostrate radiculose stems, which are sparingly villous; by the leaves, which are of two forms, the cauline being larger and squarrose, the branch-leaves obtuse, slightly papillose, roundish, and sub-erect, denticulate, and shortly two-nerved at the base; areolation oblong-hexagonal or subquadrate. Capsule cernuous; lid conic or slightly rostellate. Inner peristome with a single filiform process between each of its segments.

1. *H. heteropteron* (Br. et Schimp.). Bryol. Europ., vol. v. Monogr., p. 4, tab. 480. Rabenhor., Bryothec. Europ., Nos. 539 and 643. Hypnum heteropteron, Bryol. Brit., p. 369, tab. 26. H. atrovirens, Turner., Musc. Hib., p. 169. H. catenulatum, Muscol. Brit., Ed. 2, p. 160, tab. 24.

Hab. Moist rocks near waterfalls, and on broken ground by the margins of rivulets. Waterfall at Powerscourt, and Dargle river, Wicklow; Connemara, Galway, &c. At O'Sullivan's Cascade, Killarney, in fruit July, 1866.

68. MYURELLA. Schimp.

Stems decumbent, more or less radiculose, and stoloniferous; innovations ascending or erect. Leaves slender, cordate-ovate, obtuse or slightly pointed, shortly two-nerved at the base. Capsule ovate, cernuous, of thick texture. Peristome double, the external of 16 strong subulate-acuminate teeth, connected at base; interior peristome with teeth longer than those of the outer; their segments broadly lanceolate, irregularly divided along the keel; areolation consisting of quadrate or rhomboid hyaline cells. Inflorescence dioicous; male flowers gemmiform.

1. *M. julacea* (Br. et Schimp.). Bryol. Europ., vol. VI. Monogr., p. 3, tab. 560. Schimp., Synops. Muscor., p. 484. Hypnum moniliforme, Wahl., Fl. Lap., p. 376, tab. 24. Hook. and Tayl. Muscol. Brit., Ed. 2, p. 159. Leskea julacea, Schwaegr. L. moniliformis, Wilson, Bryol. Brit., p. 328, tab. 24.

Hab. In mountain districts. On the ground among other mosses in Connemara, J. T. Mackay, in Flor. Hib. I have not seen any Irish specimens.

68*. LESKEA. Hedw.

Calyptra dimidiate or cuculliform. Capsule erect, more or less symmetrical, pedicellate, annulate. Peristome double, the exterior of 16 subulate-lanceolate, trabeculated teeth; inner peristome of 16 carinate, narrow cilia as long or longer than the outer teeth, arising from a membrane more or less deeply divided. Leaves ovate or ovate-acuminate, nerved or nerveless; areolation rather dense, composed of roundish cells. Inflorescence monoicous or dioicous.

1. *L. polycarpa* (Hedw.). Sp. Musc., p. 225. Bryol. Europ., vol. v. Monogr., p. 2, tab. 470. Wils., Bryol. Brit., p. 332, tab. 24. Hypnum medium, Dickson, Crypt. Fasc. 2, p. 12. Hook. and Taylor., Muscol. Brit., Ed. 2, p. 154. Musc. Hib., p. 142.

Hab. About the roots of trees and on stones which are covered with water during a part of the year. Not very common, but widely distributed.

69. ANOMODON. Hook. et Tayl.

Calyptra cucullate, split at side. Capsule cylindrical, long-pedicellated, erect, oblongo-cylindrical, leptodermous; lid conico-rostrate. Peristome double, exterior teeth 16; interior cilia 16, shorter than the outer teeth, slightly connected at base by a short membrane. Leaves spreading, ovate-ligulate, costate to the apex; areolation small, dense, and opaque. Nearly allied to Leskea, but of different habit.

1. *A. viticulosum* (Hook. and Tayl.). Muscol. Brit., Ed. 2, p. 138. Bryol. Europ., vol. v. Monogr., p. 5, tab. 476. Bryol. Brit., p. 318, tab. 22. Neckera viticulosa, Turner, Musc. Hib., p. 103.

Hab. Rocks and walls, especially in limestone districts. Frequent and generally distributed.

69*. Thuidium. Schimp.

Scarcely differing from Hypnum, but distinguished principally by the widely creeping stems, which are covered with short villi, and furnished with doubly or triply pinnated branches, and by the leaves being papillose and more or less plaited.

Diagnosis of Species.

Stems simply pinnate, clothed with short villi; nerved almost to the apex; leaves papillose on the back their margins reflexed, capsule cylindrical, inclined; lid conical. Inflorescence dioicous, .	1. T. abietinum.
Stems interruptedly tripinnate; leaves serrate, papillose on the back, those on the stem cordate-acuminate, nerved almost to the apex, branch-leaves ovate with a short single or double nerve, .	2. T. tamariscinum.

1. *T. abietinum* (Linn.). Sp. Pl., p. 1591. Bryol. Europ., vol. v. p. 9, tab. 485. Schimp., Synops. Muscor., p. 409. Rabenhor., Bryothec. Europ., No. 770. Hypnum abietinum, Bryol., Brit., p. 377, tab. 25. Hook. and Tayl., Muscol. Brit., p. 174.

Hab. On sandy ground near the sea coast. Portmarnock sands, Malahide and Portrane, Dublin; Belmullet, and near Killala, Mayo. Rare in Ireland.

2. *T. tamariscinum* (Hedw.). Sp. Musc., p. 261, tab. 67, f. 1–5, Bryol. Europ., vol. v. Monogr., p. 7, tab. 482, 483. Schimp., Synops. Muscor., p. 498. Hypnum tamariscinum, Bryol. Brit., p. 380, tab. 57. H. proliferum, Hook. and Tayl. Muscol. Brit., p. 171. Engl. Bot., tab. 1494.

Hab. Woods and shady banks. Abundant in many parts of the country.

Sub-tribe. *Camptothecieæ.*

70. Hypnum. Linn. et Dillen.

Calyptra dimidiate, small, fugacious. Capsules more or less ovate, sub-cylindrical or unequal, generally arcuate-cernuous. Peristome double, the exterior of 16 linear lanceolate teeth, trabeculated, and marked by a medial line; inner peristome a membrane divided half way down into 16 carinated processes or cilia, alternating with the outer teeth; intermediate ciliolæ present 1–3 together between each pair. Inflorescence monoicous, dioicous, or polygamous.

A very comprehensive Genus of mosses as it stands in the older works; but latterly it has been subdivided into genera, most of which are adopted as sections here.

Sect. 1. *Brachythecium.* Bryol. Europ.

Plants mostly large and robust; stems spreading widely, rarely suberect, profusely branched; branches irregular or sub-pinnate. Leaves silky, crowded, spreading on every side, rarely secund, ovate or ovate-lanceolate, margins recurved below; areolation rhomboid or more elongated. Capsules ovate or oblong, cernuous, or sub-erect; lid convex-conic: teeth of peristome, densely trabeculate, cilia rarely absent.

Diagnosis of Species.

Inflorescence dioicous.

Leaves erecto-patent, lanceolate-acuminate, entire, striated, nerved nearly to the apex; fruit-stalk rough, . . . 1. H. LUTESCENS.

Leaves erect, ovate-lanceolate, imbricated, striated, concave, entire, revolute at the margin, nerved half way, . . . 2. H. ALBICANS.

Leaves densely imbricated, ovate, patent, with long slender points, nerved above half way; fruit-stalk smooth, . . 3. H. GLAREOSUM.

Leaves patent, ovate, striated, margin sharply serrated, nerved above half way; fruit-stalk rough, ... 4. H. RIVULARE.

Leaves closely imbricate, ovate-apiculate, concave, serrulate, nerve ceasing below the apex; fruit-stalk roughish, . . 5. H. ILLECEBRUM.

Inflorescence monoicous.

Leaves spreading, sub-secund, ovate, or lanceolate-acuminate, serrate, nerved half way; fruit-stalk rough, . . . 6. H. VELUTINUM.

Leaves erect, ovate, or lanceolate-acuminate, their margins slightly reflexed, nerve excurrent; fruit-stalk roughish, . 7. H. POPULEUM.

Leaves erecto-patent, the upper sub-secund, ovate-lanceolate, subserrate, their margins recurved, nerved half way; fruit-stalk roughish, ... 8. H. PLUMOSUM.

Leaves ovate-acuminate, sub-serrate, slightly striated, nerve reaching above half way; fruit-stalk slightly rough, . . 9. H. MILDEANUM.

Leaves ovate-acuminate, serrate, striate, nerved half way to apex; fruit-stalk rough, ... 10. H. RUTABULUM.

1. *H.* (*Brachythecium*) *lutescens* (Hudson). De Notr., Briol. Ital., p. 113. Hypnum lutescens, Bryol. Brit., p. 115, tab. 25. Camptothecium lutescens, Bryol. Europ., vol. IV. Monogr., p. 6, tab. 558. Schimp., Synops. Muscor., p. 528. Rabenhor., Bryothec. Europ., No. 592.

Hab. Rocks and sands near the sea. Portmarnock, Malahide, and Portrane, Dublin; near Arklow, Wicklow; near Killala, Mayo, &c. Fruiting at Blarney, Dr. Power, in Fl. Cork.

2. *H.* (*Brachythecium*) *albicans* (Dill.). Bryol. Europ., vol. VI. Monogr., p. 19, tab. 553. Schimp., Synops. Muscor., p. 538. Hypnum albicans, Bryol. Brit., p. 337, tab. 25. Engl. Bot., tab. 1300. Hook. and Taylor, Muscol. Brit., p. 167.

Hab. On sands near the sea shore. Abundant at Portmarnock, Malahide, and Portrane, Dublin, where it fruits freely. Generally distributed.

3. *H.* (*Brachythecium*) *glareosum* (Br. et Schimp.). Bryol. Europ., vol. VI. Monogr., p. 19, tab. 552. Schimp., Synops. Muscor., p. 553. Rabenhor., Bryothec. Europ., No. 544. Hypnum glareosum, Bryol. Brit., p. 338, tab. 55.

Hab. On grassy banks. Abundant about Glasnevin, and other places near Dublin, Wicklow, Connemara, &c.

4. *H.* (*Brachythecium*) *rivulare* (Br. et Schimp.). Bryol. Europ., vol. VI. Monogr., p. 13, tab. 549. Schimp., Synops. Muscor., p. 543. Rabenhor., Bryothec. Europ., No. 746. Hypnum rivulare, Bryol. Brit., p. 346, tab. 55.

Hab. On dripping rocks and watery places by the sides of rivulets, &c. Ballinascorney Glen, and Kelly's Glen, Dublin; wet rocks between Arklow and Wooden-bridge, Wicklow; Connemara; Brandon, Kerry; Dodge's Glen, Cork, Isaac Carroll.

5. *H.* (*Brachythecium*) *illecebrum* (Schwaegr.). De Notr., Briol. Ital., p. 113. Hypnum illecebrum, Bryol. Brit., p. 343, tab. 35.

Hab. Banks and rocks thinly covered with earth. Killiney and Howth, Dublin; Ballinascorney, D. Orr. On an old wall near Clonmel; abundant and fruiting freely in the burying-ground, at Queenstown, Cork, Isaac Carroll.

6. *H.* (*Brachythecium*) *velutinum* (Linn.). Sp. Plant., p. 1595. Bryol. Europ., vol. VI. Monogr., p. 5, tab. 538, Schimp., Synops. Muscor., p. 536. Hypnum velutinum, Bryol. Brit., p. 342, tab. 26. Engl. Bot., tab. 1568. Hook. and Taylor, Muscol. Brit., p. 177.

Hab. Stones, walls, and banks near trees. Frequent in most parts of Ireland. In fine condition creeping over large stones on Howth.

7. *H.* (*Brachythecium*) *populeum* (Hedw.). Sp. Musc., tab. 70, f. 1–6. Bryol. Europ., vol. VI. Monogr., p. 3, tab. 535–536. Schimp., Synops. Muscor., p. 544. Rabenhor., Bryothec. Europ., No. 1041. Hypnum populeum, Bryol. Brit., p. 341, tab. 24. Hook. and Taylor, Muscol. Brit., p. 157.

Hab. On rocks, walls, and trees. Common in many parts of Ireland.

8. *H.* (*Brachythecium*) *plumosum* (Swartz.). Muscol. Suec., p. 66. Bryol. Europ., vol. VI. Monogr., p. 4., tab. 537. Schimp., Synops. Muscor., p. 545. Rabenhor., Bryothec. Europ., No. 1040. Hypnum plumosum, Bryol. Brit., p. 240, tab. 25. Turner, Musc. Hib., p. 172.

Hab. Wet rocks on the banks of rivulets and in shady places. Common, particularly in hilly parts of the country.

9. *H.* (*Brachythecium*) *Mildeanum* (Schimp.). Rabenhor., Bryothec. Europ., No. 772. Hypnum salebrosum, Bryol. Brit., p. 338, tab. 53 (in part).

Hab. Grassy banks and sand-hills. Between Malahide and Portrane, Dublin; near Dunfanaghy, Donegal; limestone quarries, Cork, Isaac Carroll. Very rare in Ireland, and not hitherto found in fruit.

10. *H.* (*Brachythecium*) *rutabulum* (Linn.). Sp. Pl., p. 1590. Bryol. Europ., vol. VI. Monogr., pp. 543–544. Schimp., Synop. Muscor., p. 542. Hypnum rutabulum, Bryol. Brit., p. 345, tab. 26. Turner, Musc. Hib., p. 179. Hook. and Taylor, Musc. Brit., p. 76.

Hab. Trees, rocks, walls, and banks. One of the commonest of our mosses.

Sect. *Rhynchostegium* Bryol. Europ.

Distinguished by the long rostellate operculum, by the position of the capsules, by the teeth of the peristome being distinctly lamellated on their outer surface, by the tissue of the leaves being composed of long, narrow, hexagonal, rhomboidal areolæ, and by the mode of growth. *Eurhynchium* of Schimper is included in this section.

Diagnosis of Species.

Fruit-stalks smooth. Inflorescence monoicous.

Stem creeping, branched, branches procumbent; leaves loosely imbricated, spreading, ovate-acute, margins serrate, nerve not quite percurrent, ...	11. H. RUSCIFORME.
Stem creeping, subpinnate; leaves erecto-patent or sub-secund, ovate-acuminate, concave, nerved half way, serrulate, .	12. H. CONFERTUM.
Stem lax, with innovations, branched, branches round or sub-complanate; stem leaves spreading, and sub-deltoid, ovate-acuminate, those of the branches imbricated, all nerved two-thirds to the apex, denticulate; capsule oblong, nearly horizontal, ...	13. H. MEGAPOLITANUM.
Stem creeping, much branched; leaves nearly erect, imbricated, roundish-ovate, nerved more than half-way, ...	14. H. MURALE
Stem creeping, branches sub-erect, fasciculate; leaves lanceolate-subulate, erect, entire, nerve percurrent, ...	15. H. TENELLUM.
Stem prostrate, creeping, sparsely branched; leaves erecto-patent, sub-secund, lanceolate, entire, nerveless, margin slightly reflexed, ...	16. H. DEMISSUM.
Stem prostrate, pinnately subdivided; leaves slightly concave and compressed, ovate, acute, serrulate, shortly two-nerved at the base; capsule ovate-oblong, curved or subcernuous; lid rostrate; inflorescence dioicous, ...	17. H. DEPRESSUM.

Stem prostrate, creeping, sparsely branched; leaves spreading, roundish, sub-secund, apiculate, concave, serrulate, obscurely two-nerved at base, ... 18. H. MICANS.

Fruit-stalks smooth. Inflorescence dioicous.

Stem arched or procumbent, sub-pinnate; leaves patent, cordate-acuminate, serrate, striate, nerved more than half way to apex, ... 19. H. STRIATUM.

Stem creeping, densely tufted; leaves spreading, ovate-acuminate, sub-striate, serrate, nerved two-thirds to the apex, 20. H. STRIATULUM.

Stem rhizomatous, branches arcuate, sub-fasciculate; leaves narrowly ovate-acuminate, sub-secund, serrulate, nerved almost to the apex, ... 21. H. CIRCINATUM.

Stem fascicled, curved; leaves lanceolate-acuminate, serrate, nerved nearly half way to apex, ... 22. H. MYOSUROIDES.

Stem creeping or decumbent, sub-pinnate; leaves imbricate, spreading, triangularly ovate; branch leaves smaller, ovate-lanceolate, concave, serrate, nerved more than half way, . . 23. H. STRIGOSUM.

Fruit-stalks rough.

Stem procumbent, pinnately branched; leaves ovate-elongate, acuminate, with piliform points at apex, serrulate, nerved half way, ... 24. H. PILIFERUM.

Stems creeping, with erect branches; leaves patent, widely ovate-acuminate, concave, serrate, margins reflexed, nerved more than half way, ... 25. H. CRASSINERVIUM.

Stem arched, creeping, branches sub-pinnate; leaves distant, patent; stem leaves cordate-squarrose; branch leaves lanceolate-acuminate, serrate, nerved more than half way to apex, . . . 26. H. PRÆLONGUM.

Stem procumbent and creeping, with ascending branches; leaves spreading, cordate-ovate, serrate, nerved above half-way to apex, ... 27. H. SWARTZII.

Stem creeping and procumbent, sub-pinnate; leaves small, spreading, ovate-serrulate; branch leaves ovate-lanceolate, acute, nerved half way, . . . 28. H. PUMILUM.

Synoicous.—Stems creeping, with erect simple branches; leaves ovate, serrulate, nerved almost to the apex, . . . 29. H. SPECIOSUM.

Monoicous.—Stems small, slender, creeping; branches erect; leaves sub-complanate, spreading, lanceolate, rigid, sub-serrulate, nerved nearly to the apex, . . 30. H. TEESDALEI.

11. *H.* (*Rhynchostegium*) *rusciforme* (Weiss). Bryol. Europ., vol. v. Monogr., p. 11, tab. 515–516. Schimp., Synops. Muscor., p. 572. Hypnum ruscifolium, Bryol. Brit., p. 354, tab. 26. Engl. Bot., tab. 1275. Hook. and Taylor, Muscol. Brit., Ed. 2, p. 177.

Hab. Waterfalls, rocks, and stones in rivulets. A very common species throughout Ireland. Mr. Wilson mentions a curious form of this plant found at Leixlip, Dublin, with elongated, cylindrical, or filiform, fasciculate branches, and smaller, roundish, very concave leaves, which are sub-secund and sub-striate when dry. He suggests that it may be the var. *alopecuroides*, mentioned by Bridel, (Bryol. Univ. 2, p. 500), as occurring "in Hiberniæ aquis."

12. *H.* (*Rhynchostegium*) *confertum* (Dicks.). Crypt. Fasc. 4, tab. 11, f. 4. Bryol. Europ., vol. v. Monogr., p. 7, tab. 510. Schimp., Synops Muscor., p. 568. Hypnum confertum, Bryol. Brit., p. 355, tab. 26. Engl. Bot.. tab. 2407. Muscol. Brit., p. 178.

Hab. On trunks of trees, and on stones and walls. Generally distributed, though not very abundant.

13. *H.* (*Rhynchostegium*) *megapolitanum* (Blandow.) Bryol. Europ., vol. v. Monogr., p. 8, tab. 511 Schimp., Synops. Muscor., p. 569. Rabenhor., Bryothec. Europ., No. 486. Hypnum megapolitanum, De Notr., Mant., No. 22.

Hab. Fields and sand-hills. Between Portrane and Malahide; in fruit, November, 1858; Dingle Bay, Kerry, Dr. Carrington, 1868.

14. *H.* (*Rhynchostegium*) *murale* (Dill.). Musc., tab. 41, f. 52. Bryol. Europ., vol. v. Monogr., p. 10, tab. 514. Schimp., Synops. Muscor., p. 571. Rabenhor., Bryothec. Europ., No. 384. Hypnum murale, Bryol. Brit., p. 356, tab. 24. Hook. and Taylor, Muscol. Brit., p. 161.

Hab. On walls and stones, chiefly in limestone districts. St. Margaret's, Botanic Gardens at Glasnevin, and Howth, Dublin; near Clonmel, Tipperary.

15. *H.* (*Rhynchostegium*) *tenellum* (Dicks.). Crypt. Fasc., p. 4. tab. 11, f. 12. Bryol. Europ,, vol. v. Monogr., p. 5, tab. 508, Schimp., Synops. Muscor., p. 565. Rabenbor., Bryothec. Europ., No. 542. Hypnum tenellum, Bryol. Brit., p. 35, tab. 24. Turner, Musc. Hib. p. 170. Engl. Bot. tab. 1859.

Hab. On rocks and walls, chiefly those that are calcareous. Generally distributed through Ireland.

16. *H.* (*Rhynchostegium*) *demissum* (Wilson). Engl. Bot. Suppl., tab. 2740. Bryol. Europ., vol. v. Monogr., p. 4, tab. 507. Rabenhor., Bryothec. Europ., No. 541. Hypnum demissum, Bryol. Brit., p. 401, tab. 59.

Hab. On the inclined faces of shady rocks. Cromagloun, and near O' Sullivan's Cascade, Killarney, W. Wilson and George Hunt; Glengarriff, Miss Hutchins; near Kenmare, Dr. Taylor; and elsewhere at Killarney.

17. *H.* (*Rhynchostegium*) *depressum* (Br. et Schimp.). Bryol. Europ., vol. v. Monogr., p. 8, tab. 512. Rabenhor., Bryothec. Europ., No. 796. Hypnum depressum, Bryol. Brit., p. 409, tab. 59.

Hab. On rocks, stones, and shady banks. Plentiful at Killarney and Cromagloun, Kerry; but rare elsewhere in Ireland. A variety with narrower and more acute leaves was collected near Torc Waterfall, Killarney, by Dr. Taylor, as noticed in Bryol. Brit., p. 409.

18. *H.* (*Rhynchostegium*) *micans* (Wilson). Bryol. Brit., p. 402. tab. 59. Hypnum micans, Wilson in Hook. Br. Fl., p. 86. Taylor, Fl. Hib. p. 42. H. elegans, Turner, MS. in Herb. Turner.

Hab. On the faces of shady rocks. Woods at Glengarriff, Miss Hutchins; in the woods at Killarney, W. Wilson, Dr. Taylor, and George Hunt. Not yet found in fruit. Probably a species of Leskea.

19. *H.* (*Rhynchostegium*) *striatum* (Schreb.). Fl. Lips., p. 91. Briol. Ital., p. 76. Eurhynchium striatum, Schimp., Synops. Muscor. p. 553. Hypnum striatum, Bryol. Brit,, p. 352, tab. 26. Turner, Musc. Hib., p. 180. Engl. Bot., tab. 1648. Muscol. Brit., p. 178.

Hab. Woods and banks. Botanic Gardens, Glasnevin; Benbulben, Sligo; Killarney; Castle Taylor, Galway. Not very common in Ireland.

20. *H.* (*Rhynchostegium*) *striatulum* (Spruce).—Briol. Ital., p. 78. Eurhynchium striatulum, Bryol. Europ., vol. v. Monogr., p. 5, tab. 522. Rabenhor., Bryothec. Europ., No. 388. Hypnum striatulum, Bryol. Brit., p. 352, tab. 55.

Hab. Woods at Killarney, W. Wilson; Devil's Glen, Wicklow. Apparently rare.

21. *H.* (*Rhynchostegium*) *circinatum* (Bridel). Sp. Musc. et Mant. Musc. Briol. Ital., p. 78. Eurhynchium circinatum, Bryol. Europ., vol. v. Monogr., p. 4, tab. 521. Schimp., Synops. Muscor., p. 551. Rabenhor., Bryothec. Europ., No. 594. Hypnum circinatum, Bryol. Brit.., p. 353, tab. 55.

Hab. On rocks and walls in limestone districts. Castle Martyr, where I collected this moss, in company with Isaac Carroll; also near Fermoy, Cork. On limestone rocks, Innisfallen, and other islands in Lough Leane, Killarney, Dr. Carrington. Rare in Ireland.

22. *H.* (*Rhynchostegium*) *myosuroides* (Linn.). Sp. Plant., p. 159. Briol. Ital., p. 79. Isothecium myosuroides, Bryol. Europ., vol. v. Monogr., p. 7, tab. 534. Bryol. Brit., p. 323, tab. 25, Hypnum myosuroides, Turner, Musc. Hib., p. 140. Hook. and Taylor, Muscol. Brit., p. 169.

Hab.. On shady rocks, trunks of trees, &c. Very common in many parts of the country.

23. *H.* (*Rhynchostegium*) *strigosum* (Hoffm.). Deutsch. Flor. 2, p. 76. Briol. Ital., p. 80. Eurhynchium strigosum, Bryol. Europ., vol. v. Monogr., p. 2, tab.. 519. Rabenhor., Bryothec. Europ., No. 745. Hypnum strigosum, Bryol. Brit., p. 353, tab. 55.

Hab. At the roots of trees and on banks. A barren moss found by D. Orr, near Sallygap, Dublin, has been doubtfully referred to this species, and this is the only instance of its occurrence in Ireland.

24. *H.* (*Rhynchostegium*) *piliferum* (Schreb.). Fl. Lips., p. 91. Briol. Ital., p. 82. Eurhynchium piliferum, Bryol. Europ., vol. v. Monogr., p. 16, tab. 531. Schimp., Synops. Muscor., p. 557. Rabenhor., Bryothec. Europ., No. 144. Hypnum piliferum, Bryol. Brit., p. 347, tab. 25.

Hab. Woods and shady banks. Widely distributed, but rare in fruit.

25. *H.* (*Rhynchostegium*) *crassinervium* (Taylor). Flor. Hib., p. 43. Briol Ital., p. 83. Eurhynchium crassinervium, Bryol. Europ., vol. v. Monogr., p. 14, tab. 529. Schimp., Synops. Muscor., p. 555. Rabenhor., Bryothec. Europ, No. 335. Hypnum crassinervium, Bryol. Brit., p. 346, tab. 55.

Hab. Rocks and banks in limestone districts. Common about Dunkerron, Taylor in Fl. Hib.; and at Muckross, Kerry; Castle Taylor, Galway; Mardyke, and near Fermoy, Cork. Apparently confined to the southern and western counties.

26. *H.* (*Rhynchostegium*) *prælongum* (Dill.). Musc., tab. 35, f. 15 A. Bryol. Ital., p. 84. Eurhynchium prælongum, Schimp., Synops. Muscor., p. 559. Rabenhor., Bryothec. Europ., No. 480. Hypnum prælongum, Bryol. Brit., p. 348, tab. 25. Turner, Musc. Hib., p. 160. Engl. Bot., tab. 2035. Muscol. Brit., p. 172. Var. β *Stokesii*, Bryol. Brit.—Hypnum Stokesii, Turner, Muscol. Hib., p. 159, tab. 15.

Hab. Moist shady banks and rocks frequent. Var. β at Lough Bray, Dr. Whitley Stokes; between Wooden-bridge and Arklow, Wicklow; near Clonmel, Tipperary; Killarney; Rockingham, Roscommon.

27. *H.* (*Rhynchostegium*) *Swartzii* (Turner). Eurhynchium prælongum, Bryol. Europ. Rabenhor., Bryothec. Europ. No. 593. Hypnum Swartzii, Musc. Hib., p. 151, tab. 14, f. 1. Bryol. Brit., p. 349, tab. 55. Engl. Bot., tab. 2034.

Hab. Wet sides of ditches and shady banks. Abundant near Dublin, but rare in fruit; Killarney, Kerry; Castle Taylor, Galway.

28. *H.* (*Rhynchostegium*) *speciosum* (Bridel). Mant. Musc., p. 156. R. androgynum, Bryol. Europ.—Rabenhor., Bryothec. Europ., No. 595. Hypnum speciosum, Bryol. Brit., p. 349, tab. 55.

Hab. Damp places, and about the roots of trees. Near Cork, Isaac Carroll; at Killarney, Kerry. Apparently rare in Ireland.

29. *H.* (*Rhynchostegium*) *Teesdalei* (Smith). Engl. Bot., tab. 202. Hypnum Teesdalii, Bryol. Brit., p. 350, tab. 55. Turner, Musc. Hib., p. 150. Eurhynchium Teesdalii, Lindberg, in "Journal of Linnæan Society," vol. XIII., No. 66, p. 66.

Hab. Moist rocks, and on trees. Near Bantry, Cork, Miss Hutchins; Botanic Gardens, Glasnevin, D. Orr; on trees, Phœnix Park, Dublin, sparingly.

30. *H.* (*Rhynchostegium*) *pumilum* (Wilson). De Notr., Briol. Ital., p. 87. Eurhynchium pumilum, Schimp., Synops. Muscor., p. 561. Hypnum pumilum, Bryol. Brit., p. 35, tab. 55. H. pallidirostre, Bridel, *fide* Lindberg, in "Journal of Linnæan Society," vol. XIII., No. 16, p. 16.

Hab. About the roots of trees, and on the ground in shady places. Antrim, Templeton in Herb. Turner; Kerry, Miss Hutchins. Abundant in Botanic Gardens, Glasnevin; Douglas, near Cork, Wilson; Great Island, Cork, Isaac Carroll.

Sect. *Amblystegium.* Bryol. Europ.

Plants mostly small and slender. Stems creeping and irregularly branched. Leaves spreading, rarely bifarious, mostly ovate or ovate-lanceolate; areolation hexagonal-rhomboid. Capsule oblong or cylindrical; teeth of peristome rather long; inner cilia perfect or rudimentary.

Diagnosis of Species.

Monoicous.

Stem rigid; branches pinnate; leaves subsecund, falcate-acuminate, sub-serrulate, strongly nerved to the apex, . 32. H. IRRIGUUM.

Stem procumbent; branches flaccid; leaves ovate-acuminate, concave, acute, entire; nerve strong, excurrent, . . . 33. H. FLUVIATILE.

Stem creeping, sub-pinnate; leaves ovate-lanceolate, acuminate, entire; nerved about half way, ... 34. H. SERPENS.

Stem procumbent, sub-pinnate; leaves ovate-lanceolate, acuminated, entire; nerve not quite excurrent, ... 65. H. RIPARIUM.

32. *H.* (*Amblystegium*) *irriguum* (Wilson). Bryol. Europ., vol. VI. Monogr., p. 11, tab. 566. Schimp., Synops., Muscor., p. 594. Rabenhor., Bryothec. Europ., No. 766. Hypnum irriguum, Bryol. Brit., p. 361, tab. 25.

Hab. Borders of lakes, &c. Among the roots of willows, covered partly with water, in a stagnant part of the lake at Rockingham, Roscommon, May, 1871. This is the only locality at present known to me.

33. *H.* (*Amblystegium*) *fluviatile* (Swartz). Bryol. Europ., vol. VI., Suppl., p. 1, tab. 567. Hypnum fluviatile, Swartz, Musc. Suec., p. 68. Web. et Mohr, Bot. Tasch., p. 203. Hedw., Sp. Musc., p. 227, tab. 81, f. 4. Bryol. Brit., p. 359, tab. 55. Rabenhor., Bryothec. Europ., No. 1094.

Hab On rocks and stones in rivers and streams. On rocks in the river at Ballinhassig, near Cork, Taylor, in Fl. Hib.

34. *H.* (*Amblystegium*) *serpens* (Dill.). Bryol. Europ., vol VI., Monogr., p. 9, tab. 564. Schimp., Synops. Muscor., p. 591. Hypnum serpens, Bryol. Brit., p. 362, tab. 24. Turner, Musc. Hib., p. 168. Engl. Bot., tab. 1037.

Hab. On walls, rocks, and among roots of trees. Abundant everywhere through Ireland.

35. *H.* (*Amblystegium*) *riparium* (Linn.). Bryol. Europ., vol. VI. Monogr., p. 14, tab. 570, 571. Schimp., Synops. Muscor., p. 597. Rabenhor., Bryothec. Europ., No. 482. Hypnum riparium, Bryol. Brit., p. 364, tab. 24. Engl. Bot., tab. 2060.

Hab. On wood, and stumps of trees by the sides of rivers, &c. Frequent and generally distributed.

Sect. *Limnobium*. Bryol. Europ.

Main stems mostly prostrate, irregularly branched. Leaves varying in form, generally roundish, and rather obtuse, entire, slightly two-nerved or nerveless, cellules oblong or linear. Capsule cernuous; operculum hemispherical, apiculate, or shortly conic.

Diagnosis of Species.

Inflorescence monoicous.

Leaves secund or imbricated, ovate-acuminate, apiculate, concave, entire; their margins incurved above, nerve short, sometimes forked at the base, . . 36. H. PALUSTRE.

Leaves imbricated, adpressed, slightly secund or sub-falcate, ovate-acute; nerved nearly to the apex; capsule tumid, round or roundish-ovate, ... 37. H. SUBSPHÆROCARPUM.

Stem shortly creeping; branches sub-erect; leaves imbricated, ovate-rotund, apiculate, alar cells very large, fulvous; capsule short, wide-mouthed, annulate, cernuous, ... 38. H. EUGYRIUM.

Dioicous.

Stem sub-erect, sometimes elongated, sparingly branched; leaves secund, occasionally falcate, ovate-lanceolate, concave; nerve forked, extending to one-third the length of the leaf; basal cells large, pellucid, ... 39. H. OCHRACEUM.

36. *H.* (*Limnobium*) *palustre* (Linn.). Bryol. Europ., vol. VI. Monogr., p. 2, tab. 574, 575. Briol. Ital., p. 161. Hypnum palustre, Schimp., Synops. Muscor, p. 634. Bryol. Brit., p. 370, tab. 26. Muscol. Brit., Ed. 2, p. 185.

Hab. On stones and rocks in streams. Frequent in most parts of Ireland. It varies considerably in size, form of leaves, length of nerve, and shape of capsule.

37. *H.* (*Limnobium*) *subsphærocarpum* (De Notr.). Briol. Ital., p. 162. L. palustre, var. δ. Bryol. Europ., vol. VI. Monogr., p. 3, tab. 575, fig. 1–5. Schimp., Synops. Muscor., p. 635. Hypnum palustre, var. γ, subsphæricarpon, Bryol. Brit., p. 370.

Hab. On stones in streamlets, flowing from the hills between Cushendall and Ballymena, Antrim; near Carrickfergus, Rev. C. A. Johns.

38. *H.* (*Limnobium*) *eugyrium* (Schimper). Rabenhor., Bryothec. Europ., No. 650. Hypnum palustre, var. β. Wilson. Bryol. Brit., p. 370, in part.

Hab. On rocks in the stream below Torc Waterfall, and on rocks in a stream flowing from Purple Mountain to the Upper Lake, between O'Sullivan's Cascade and Lady Kenmare's Cottage, Killarney.

39. *H.* (*Limnobium*) *ochraceum* (Turner). Bryol. Europ., vol. VI., Suppl. tab. 580. Rabenhor., Bryothec. Europ., No. 844. Hypnum ochraceum, Turner, in Herb.—Bryol. Brit., p. 400, tab. 58.

Hab. On stones and loose earth on the banks of mountain rivulets. Plentiful in a fruiting state by the side of the stream in Kelly's Glen, Dublin, 1839. Stream at O'Sullivan's Cascade, Killarney; Connemara, Galway, &c.

Sect. *Hypnum.* Bryol. Europ.

Capsules mostly leptodermous, ovate-oblong or roundish, inclined, erecto-cernuous or cernuous; lid hemispherical, conic-mammillate or mucronate; segments of inner peristome carinate, entire, or here and there slightly perforated. Leaves squarrose, subsquarrose, secund or falcate-secund, costate, ecostate, or shortly bicostate; areolation compact; cellules linear or roundish; basal cells larger, longer, and more pellucid.

Diagnosis of Species.

a. Leaves obtuse, or shortly acuminulate.

Monoicous.

Stem erect, subpinnate; leaves loose, subsquarrose, cordate, imbricated, entire; nerve reaching nearly to the apex, . 40. H. CORDIFOLIUM.

Dioicous.

Stem prostrate, pinnately branched; leaves crowded, oblong-ligulate; obtuse, subcucullate at apex, nerve reaching nearly to point of leaf, ... 41. H. SARMENTOSUM.

Stem subdichotomously divided; leaves loosely imbricate, erect-patent, obtuse, entire; nerve reaching half way to apex, 42. H. STRAMINEUM.

Stem prostrate; leaves ovate, nerveless, entire, the lower squarrulose, upper closely imbricate; capsule oblong, cernuous; lid conical, ... 43. H. CUSPIDATUM.

Stem erect, simply pinnate; leaves closely imbricate, ovate-acuminate, concave, apiculate, nerved half way to apex; capsule ovate, cernuous, ... 44. H. PURUM.

Stem erect, simply pinnate; branches curved; leaves closely imbricate, sub-erect, elliptical, apiculate, concave, entire, two-nerved at base; capsule ovate, cernuous, 45. H. SCHREBERI.

aa. Leaves ovate or ovate-acuminate, secund.

Dioicous.

Stem procumbent or sub-erect, sparingly and irregularly branched; branches subcomplanate; leaves complanate, sub-secund, lax, ovate-lanceolate, nerveless; capsule turgid, ovate, plicate when dry; lid conical, ... 46. H. Lindbergii.

Stem erect or procumbent, irregularly pinnate; leaves imbricate, secund, broadly ovate or roundish, nerveless or faintly two-nerved at base, falcate at the apex of the branches, ... 47. H. scorpioides.

aaa. Leaves mostly falcate, secund, nerve thin.

Stem subpinnate; cauline leaves crowded, secund; branch leaves falcate-secund, ovate-acuminate, concave, large, nerved nearly to the apex. Dioicous, . . 48. H. lycopodioides.

Stem subpinnate; branches simple, uncinate; cauline leaves broadly ovate at base; branch leaves falcate-secund, lanceolate-subulate, concave, slightly striate, nerve reaching half way. Dioicous, . . 49. H. vernicosum.

Stems crowded, erect or procumbent, leaves circinate, secund, ovate-acuminate, subserrulate at the apex, nerve reaching above half way up. Monoicous, . 50. H. revolvens.

Stem pinnately branched; leaves circinate, secund, ovate-acuminate. Dioicous, . 51. H. intermedium.

Stem erect or procumbent, pinnate; leaves falcate-secund, lanceolate-subulate from a broad base, serrate, striate, nerve reaching almost to the apex. Monoicous, 52. H. uncinatum.

Stem flaccid, elongate, branches pinnate; leaves rather loose, secund, falcate, ovate-acuminate, channelled or striated; nerved to the apex; capsule exannulate. Dioicous, ... 53. H. exannulatum.

Stem erect or floating, pinnate; leaves loosely imbricated, uppermost falcate-secund, ovate-lanceolate, subserrulate at the apex; nerved above half way; capsule exannulate. Monoicous, ... 54. H. FLUITANS.

Stem erect, pinnate; cauline leaves distant, loose, cordate-lanceolate, branch-leaves subsecund, lanceolate-acuminate, entire; nerved more than half way. Dioicous, . 55. H. KNEIFFII.

aaaa. Leaves serrulate, nerved above half way to apex.

Stem procumbent, radiculose, pinnate; leaves falcate-secund, cordate at base, elongate-acuminate, plicate; nerve not quite excurrent. Dioicous, ... 56. H. COMMUTATUM.

Stem sub-erect, branches pinnate; leaves falcate-secund, spreading, ovate-acuminate; nerve percurrent. Dioicous, . . . 57. H. FILICINUM.

Stems with innovations, crowded, pectinately branched; leaves of the branches falcate, circinate.

Stems pinnate, sub-erect, much crowded; leaves falcate-secund, cordate-acuminate, serrate, slightly striate, with two short nerves; capsule ovate, cernuous, lid conical. Dioicous, ... 58. H. MOLLUSCUM.

Stems procumbent, pinnate; leaves circinate-secund, tapering into acuminate, narrow points, nerveless; capsule subcylindrical, arcuate. Monoicous, . . . 59. H. HAMULOSUM.

Stems procumbent, subpinnate; leaves falcate-secund, ovate-lanceolate, acuminate, scarcely serrulate; nerveless, or shortly two-nerved at base; capsule cylindrical, erecto-cernuous; lid conico-rostellate. Dioicous, ... 60. H. CUPRESSIFORME.

aaaaa. Leaves squarrose, shortly nerved or nerveless.

Stem creeping or procumbent, irregularly branched; leaves subsquarrose, spreading, ovate-lanceolate, acuminate, entire, nerved half way; capsule subcernuous; lid conical. Polygamous, ... 61. H. POLYGAMUM.

Stems erect, densely tufted, subpinnately branched; leaves squarrose, cordate-acuminate, entire, nerveless. Dioicous, . 62. H. STELLATUM.

Stems procumbent or sub-erect, pinnately branched; leaves subsquarrose, subsecund, cordate, ovate-acuminate, nerved half way. Dioicous, ... 63. H. CHRYSOPHYLLUM.

Stem erect or procumbent, sparingly branched; branches pinnate, erect, slender; leaves spreading, subsquarrose or subsecund, acuminate, entire, nerveless; capsule oblong, cernuous; lid conical. Monoicous, 63. H. POLYMORPHUM.

Stem slender, procumbent, subpinnate; leaves squarrulose at base, loosely imbricate, spreading, upper subsecund, lanceolate-acuminate, nerved nearly to apex; capsule subcylindrical incurved. Dioicous, 64. H. ELODES.

40. *H. cordifolium* (Hedw.). St. Crypt., p. 4, tab. 37, vol. VI. Monogr., p. 47, tab. 617. Bryol. Europ., Schimp., Synops. Muscor., p. 641. Bryol. Brit., p. 374, tab. 56. Muscol. Brit., Ed. 2, p. 179.

Hab. Bogs and marshy places. Frequent, and generally distributed through Ireland.

41. *H. sarmentosum* (Wahlenb.). Bryol. Europ., vol. VI. Monogr., p. 48, tab. 616. Schimp., Synops. Muscor., p. 643. Bryol. Brit., p. 374, tab. 56. Rabenhor., Bryothec. Europ., No. 149.

Hab. Wet rocks in subalpine situations. Brandon mountain, and Carrantuohill, Kerry.

42. *H. stramineum* (Dicks.). Bryol. Europ., vol. VI. Monogr., p. 49, tab. 617. Schimp., Synops. Muscor., p. 646. Bryol. Brit., p. 373, tab. 56. Turner, Musc. Hib., p. 164. Engl. Bot., tab. 2465.

Hab. Marshes, heaths, and sandy places. Not very common, but occurs in many of the counties in Ireland. Fruiting on the margins of the stream in Kelly's Glen, Dublin, half buried in sandy debris; on sandy banks at Magilligan, Derry, 1835.

43. *H. cuspidatum* (Dill.). Musc., tab. 39, f. 34. Bryol. Brit., p. 375, tab. 26. Bryol. Europ., Monogr., p. 51, tab. 619. Turner, Musc. Hib., p. 177. Engl. Bot., tab. 2407.

Hab. Marshy ground and bogs. Frequent through Ireland.

44. *H. purum* (Linn.). Sp. Plant., p. 1594. Bryol. Europ., vol. VI. Monogr., p. 52, tab. 621. Schimp., Synops. Muscor., p. 646. Bryol. Brit., p. 376, tab. 24. Turner, Musc. Hib., p. 175, Muscol. Brit., p. 162.

Hab. Shady banks, among rocks and stones. Frequent, and generally distributed, particularly in limestone districts.

45. *H. Schreberi* (Willd.). Fl. Berol., p. 325. Bryol. Europ., vol. VI. Monogr., p. 54, tab. 620. Schimp., Synops. Muscor., p. 645. Bryol. Brit., p. 376, tab. 24. Turner, Musc. Hib., p. 176. Muscol. Brit., Ed. 2, p. 159.

Hab. Heaths and banks. A very common species, generally distributed, usually occurring about the roots of heath.

46. *H. Lindbergii* (Mitten), in Seemann's Journal of Botany, vol. II., p. 122 (1864). *H. arcuatum* (Lindberg) in Oefversight af K. Vetenskaps Akad. Förhandlingar., 1861.

Hab. Damp sandy ground. Near Lough Bray, and on the ascent to Lugnaquillia mountain, Wicklow. Without fruit in both localities.

47. *H. scorpioides* (Linn.). Sp. Pl., 1592. Bryol. Europ., vol. VI. Monogr., p. 44, tab. 612. Schimp., Synops. Muscor., p. 650. Bryol. Brit., p. 400, tab. 27. Turner, Musc. Hib., p. 187, Muscol. Brit., p. 188.

Hab. Bogs and marshy places, but rare in fruit. Plentiful in fruit in a bog near Belturbet, Cavan. When growing in water this species attains a large size. I have seen it 9 inches long in bog holes near Multifarnham, Westmeath.

48. *H. lycopodioides* (Necker). Bryol. Europ., vol. VI. Monogr., p. 45, tab. 613–614. Schimp., Synops. Muscor., p. 607. Bryol. Brit., p. 390, tab. 58. Engl. Bot. 2250. Rabenhor., Bryothec. Europ., No. 752.

Hab. Bogs and marshes. Frequent in many parts of Ireland. Fruiting in a bog, parish of Rasharkin, Co. Antrim, 1835.

49. *H. vernicosum* (Lindberg). Hypnum aduncum, var. tenue, Br. et Sch., Bryol. Europ., vol. VI. Monogr., p. 36. Wilson Bryol. Brit., p. 389. Hypnum pellucidum, Wils. MS. Hypnum aduncum, Hedw., *fide* Wilson in "Naturalist," 15th June, 1865. Hunt in Literary and Philosophical Society of Manchester Proceedings, 1866–7.

Hab. Bogs and marshes, Dublin, D. Orr; Lough Bray, Wicklow; Benbulben, Sligo, and near Killarney. I do not well understand this species, but Mr. Wilson and Mr. Hunt have so named my specimens which I sent to them.

50. *H. revolvens* (Swartz). Bryol. Europ., vol. VI. Monogr., 32, tab. 601. Schimp., Synops. Muscor., p. 610. Bryol. Brit., p. 388, tab. 58. Turner, Musc. Hib., p. 188.

Hab. Marshes and bogs. Near Swanlinbar. Dr. Scott; Seecaun and Seefin mountains, Dublin, Taylor. Killarney and Brandon, Kerry; near Kylemore, Galway. Not rare in Ireland.

It was for the discovery of this moss and *Schistidium maritimum*, and for "a vegetable substance," found in the bed of a rivulet in Queen's County, that Dr. Robert Scott received a premium of £17 1*s*. 3*d*. from the Dublin Society, in 1803, at the same time that £5 13*s*. 9*d*.* was awarded to Mr. Templeton for *Rosa Hibernica*. Dublin Society Proceedings, xxxix., p. 82 (1803).

51. *H. intermedium* (Lindberg). Hypnum Cossoni. Schimp., Musc. Europ., Suppl. III., IV. Hypnum Sendtnerii, Wils. in "Naturalist," June 15, 1865.

Hab. Bogs and marshes. In a bog near Cong, county of Galway, April, 1872. Male plant only.

Our plant bears a very great resemblance to *H. revolvens*, in general aspect, differing from that species chiefly by its more pinnately branched stems and dioicous inflorescence.

52. *H. uncinatum* (Hedw.). Bryol. Europ., vol. VI. Monogr., p. 31, tab. 600. Schimp., Synops. Muscor., p. 612. Bryol. Brit., p. 394, tab. 26. Turner. Musc. Hib., p. 190. Engl. Bot., tab. 1600. Muscol. Brit., Ed. 2, p. 187.

Hab. Walls, rocks, and roots of trees. Luggielaw, Wicklow; Killakee, Dublin; D. Orr. Glencar, Kerry. Rather rare.

53. *H. exannulatum* (Gumb.). Bryol. Europ., vol. VI. Monogr., p. 34, tab. 603. Schimp., Synops. Muscor., p. 608. Hypnum. aduncum, Bryol. Brit., p. 389, tab. 26. Carruthers in Seemann's Journal of Botany, vol. I., p. 228 (1863). Rabenhor., Bryothec. Europ., No. 754.

Hab. Marshy places in upland situations. Howth, D. Orr. Near Stepaside and other places in Co. Dublin.

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* These two sums being fifteen and five guineas in the Irish currency of the day.

54. *H. fluitans* (Dill.). Bryol. Europ., vol. VI. Monogr., p. 33 tab. 602. Schimp., Synops. Muscor., p. 609. Bryol. Brit., p. 387, tab. 58.

Hab. Marshes and lakes among the mountains. Frequent and generally distributed through Ireland.

55. *H. Kneiffii* (Schimp.), Synops. Muscor., p. 605. Bryol. Brit, p. 390, tab. 58. Rabenhor., Bryothec. Europ., No. 692. Amblystegium Kneiffii, Bryol. Europ., tab. 573.

Hab. Swampy places. Among sand-hills between Malahide and Portrane, Dublin. Near Arklow, Wicklow.

56. *H. commutatum* (Dill.). Bryol. Europ., vol. VI. Monogr., p. 38, tab. 607, 608. Schimp., Synops. Muscor., p. 613. Bryol. Brit., p. 393, tab. 25. Turner, Musc. Hib., p. 196, Engl. Bot., tab. 1569.

Hab. Boggy places. Frequent and generally distributed through Ireland.

57. *H. filicinum* (Linn.). Bryol. Europ., vol. VI. Monogr., p. 40, tab. 609. Bryol. Brit., p. 392, tab. 26. Turner, Musc. Hib., p. 197. Engl. Bot., tab. 1569.

Hab. Wet rocks, and on the dripping sides of streamlets, especially in calcareous districts. Frequent and generally distributed.

58. *H. molluscum* (Hedw.). St. Crypt., p. 4, tab. 22. Bryol. Europ., vol. VI. Monogr., p. 29, tab. 598. Schimp., Synops. Muscor., p. 634. Bryol. Brit., p. 396, tab. 27. Engl. Bot., tab. 1327.

Hab. Among damp rocks, also about the bases of trees and on banks. Abundant in limestone districts through most parts of Ireland.

59. *H. hamulosum* (Br. et. Schimp.). Bryol. Europ., vol. VI Monogr., p. 20, tab. 590. Bryol. Brit., p. 396, tab. 57. Stereodon cupressiformis, var. hamulosus, Bridel, Bryol. Univer., 2, p. 610. Rabenhor., Bryothec. Europ., No. 491.

Hab. Banks among grass and mosses in subalpine parts of the country. Near the tunnel, at the Upper Lake of Killarney, and on Brandon mountain, Kerry.

60. *H. cupressiforme* (Dill.). Musc. tab. 37, fig. 33. Bryol. Brit. p. 397, tab. 27. Bryol. Europ., vol. VI. Monogr., p. 25, tab 594, 595. Schimp., Synops. Muscor., p. 625. Turner, Musc Hib., p. 193. Engl. Bot., tab. 1860.

Hab. Rocks, trees, walls, and on the ground. **This is probably the most abundant and ubiquitous moss in Ireland. It varies** much in appearance according to the nature of the locality where it grows, while a few forms which are rather constant in their habit are indicated by Wilson and other authors. Variety γ. *minus*. Variety δ. *filiforme* are very common on trunks of of trees. Variety ε. *lacunosum* grows near Killarney, and on Connor Hill, Kerry, according to Wilson in Bryol. Brit.

61. *H. polygamum* (Br. et Schimp.). Wils., Bryol. Brit., p. 364, tab. 56. Rabenhor., Bryothec. Europ., No. 755. H. polymorphum, Hook. and Tayl. in Herb. Greville. H. nodiflorum, Wils. Amblystegium polygamum, Bryol. Europ., vol. VI. Monogr., p. 16, tab. 572.

Hab. Damp places, among sand-hills near the sea shore. Portmarnock and Malahide sands, Dublin; sands near Belmullet, and near Killala, Mayo. Variety β. *stagnatum*, (H. stagnatum, Wils., MS.), in marshy ground near Arklow, and other places on the coast of Wicklow.

62. *H. stellatum* (Dill.). Musc. tab. 39, fig. 5. Bryol. Europ., vol. VI. Monogr., p. 14, tab. 584. Schimp., Synops. Muscor., p. 603. Bryol. Brit., p. 366, tab. 26. Smith, Engl. Bot., tab. 1302. Muscol. Brit., p. 180.

Hab. Bogs and marshes. Frequent in most parts of Ireland. A large variety with broader and less acuminate leaves occurs on bogs near the Upper Lake of Killarney.

63. *H. chrysophyllum* (Bridel.). Mant. Musc., p. 175. Bryol. Brit., p. 366, tab. 26. Rabenhor., Bryothec. Europ., No. 791.

Hab. Sand-hills near the sea, and on damp soils resting on limestone inland. Malahide and Portrane, Dublin; also on the Wicklow Coast. Near Menlough, Galway, but seldom seen in fruit.

64. *H. polymorphum* (Hedw.). Sp. Musc., tab. 66. Bryol. Brit., p. 307, tab. 56. H. squarrulosum, Smith, Engl. Bot., tab. 1709. H. Sommerfeltii, De Notr., Briol. Ital., p. 173.

Hab. Damp banks and among rocks in limestone districts. Near Galway, and towards Oughterard, also near Cong. I have not seen any Irish specimens of this moss with fruit.

65. *H. elodes* (Spruce). London Journal of Botany, vol. IV., April, 1845. Bryol. Brit., p. 362, tab. 56. H. polymorphum, Flor. Hib., p. 44.

Hab. Marshy and boggy ground. In a bog near Killiney, fruiting Tayl. in Fl. Hib.; marshy ground near Black Castle, Wicklow; on the shores of Lower Lake, Killarney; shores of Lough Corrib, Galway. Rare in Ireland.

Sect. *Hylocomium.* Bryol. Europ.

Distinguished principally by the large size of the plants, and by their irregularly and distinctly pinnated stems, which for the most part are ascending, by the leaves on the stems and branches being squarrose or spreading on every side, or partly secund, and by the short roundish capsule with short lid.

Diagnosis of Species.

a. Stems villous.

Stem tripinnate; leaves ovate or elliptical, acuminulate, concave, two-nerved at the base, margins recurved, . . . 66 H. SPLENDENS.

Stem erect, arched; leaves squarrose, broadly ovate, abruptly acuminate, concave, serrated, shortly two-nerved, . . 67. H. BREVIROSTRE.

Stem pinnate, arched; branches subfasciculate; leaves thickly set, cordate-acuminate, subplicate, shortly two-nerved at base, ... 68. H. FLAGELLARE.

aa. Stems not villous.

Stem erect, subpinnate; leaves squarrose, striated, cordate-acuminate from an amplexicaul base, serrulate, two-nerved, . 69. H. TRIQUETRUM.

Stem partly erect, elongated, irregularly pinnate, leaves recurved, squarrose, subsecund, lanceolate-acuminate, concave, serrated, striated, . . . 70. H. LOREUM.

Stem partly erect, irregularly pinnate; leaves squarrose, crowded, much recurved, ovate-acuminate, serrated, two-nerved at the base, ... 71. H. SQUARROSUM.

66. *H.* (*Hylocomium*) *splendens* (Hedw.). Sp. Musc., tab. 67, f. 49. Bryol. Europ., vol. v. Monogr., p. 5, tab. 487. Schimp., Synops. Muscor., p. 652. Hypnum splendens, Bryol. Brit., p. 381, tab. 25. Turner, Musc. Hib., p. 156. Engl. Bot., tab. 1424. Muscol. Brit., p. 170.

Hab. Woods and banks. Abundant, and generally distributed.

67. *H.* (*Hylocomium*) *brevirostrum* (Ehrh.). Pl. Exsicc., No. 85. Bryol. Europ., vol. v. Monogr., p. 10, tab. 493. Schimp., Synops. Muscor., p. 655. Rabenhor., Bryothec. Europ., No. 391, Hypnum brevirostre, Bryol. Brit., p. 383, tab. 57. Muscol. Brit., p. 182.

Hab. In mountain woods chiefly. Frequent in the woods about Killarney; woods in Glencar, Sligo; glens at Cushendall, Antrim; Kylemore, Galway; and many other similar places.

68. *H.* (*Hylocomium*) *flagellare* (Dicks.). Crypt. Fasc. 2, p. 12. Hyocomium flagellare, Bryol. Europ., vol. v. Monogr., p. 2, tab. 532. Hypnum flagellare, Bryol. Brit., p. 384, tab. 57. H. umbratum, Smith, Engl. Bot., tab. 2565. Turner, Musc. Hib., p. 158.

Hab. Rocks and stones by the sides of rivulets; in the more hilly parts of the country. Fruiting in Kelly's Glen, D. Orr; on Seefin mountain, Dublin, Taylor, in Fl. Hib., Upper Lough Bray, Wicklow.

69. *H.* (*Hylocomium*) *triquetrum* (Dill.). Bryol. Europ., vol. v. Monogr., p. 8, tab. 491. Schimp., Synops. Muscor., p. 657. Hypnum triquetrum, Bryol. Brit., p. 385, tab. 26. Turner, Musc. Hib., p. 186. Muscol. Brit., Ed. 2, p. 182.

Hab. Woods and bushy places. Of frequent occurrence, and generally distributed.

70. *H.* (*Hylocomium*) *loreum* (Dill.). Musc., tab. 39, f. 38, 40, Bryol. Europ., vol. v. Monogr., p. 7, tab. 490. Schimp., Synops. Muscor., p. 658. Hypnum loreum, Bryol. Brit., p. 386, tab. 26. Muscol. Brit., Ed. 2, p. 181.

Hab. Woods and bushy places. Common, and widely distributed.

71. *H.* (*Hylocomium*) *squarrosum* (Dill.). Musc., tab. 39, f. 38 & 39., Bryol. Europ., vol. v. Monogr., p. 9, tab. 492. Schimp., Synops. Muscor., p. 656. Hypnum squarrosum, Bryol. Brit., p. 386, tab. 26. Engl. Bot., tab. 1593. Muscol. Brit., p. 182.

Hab. Woods and heathy places. Frequent and general.

Tribe 15. SKITOPHYLLEÆ.

71. FISSIDENS. Hedw.

Calyptra conic or conically attenuated. Capsule pedicellated, terminal or lateral, oval or oblong, erect or cernuous; lid conic-rostellate. Peristome single, of 16 subulate, geniculate, inflexed, teeth, cloven half way, as in Dicranum. Leaves distichously equitant, the upper part expanded into a dorsal wing, forming a vertical scalpelliform blade, usually thickened at the border; areolation dense, cellules roundish-hexagonal, and filled with chlorophyll.

Diagnosis of Species.

a. Fruit lateral.

Inflorescence monoicous.

Stems from 1 to 4 inches long, tufted, sparingly branched; leaves ovate, slightly convolute, pointed, not margined; nerve reaching nearly to the point, . .	1. F. ADIANTOIDES.
Stems short; leaves with a thick nerve, irregularly toothed to the apex; fruit lateral or sub-basilar, . . , .	2. F. DECIPIENS.

Dioicous.

Stems from one-fourth to nearly 1 inch long; leaves sheathing, slightly crenulate, lanceolate, apiculate, ...	3. F. TAXIFOLIUS.
Stems very short; leaves bordered, entire, spreading, undulated when dry, elliptical, apiculate, ...	4. F. TAMARINDIFOLIUS.

aa. Fruit terminal.

Stems very short, simple; leaves obliquely lanceolate, oblong, apiculate, denticulate, not bordered, ...	5. F. EXILIS.
Stems simple, short; leaves lanceolate, bordered, entire, ...	6. F. VIRIDULUS.
Stems short, varying from one-fourth to nearly 1 inch long; leaves broadly lanceolate, with a distinct cartilaginous border; barren flowers axillary, .	7. F. BRYOIDES.

Inflorescence dioicous.

Stems from 1 to 6 inches long, densely tufted; leaves oblong-lanceolate, rather obtuse, apiculate, not bordered; nerve ceasing below the apex, . . . 8. F. OSMUNDOIDES.

Stems elongated; leaves ligulate, entire or serrulate at the apex; lid of capsule rostrate, ... 9. F. POLYPHYLLUS.

1. *F. adiantoides* (Hedw.). St. Crypt., p. 3, tab. 26. Bryol. Europ., vol. I. Monogr., p. 10. tab. 105. Schimp., Synops. Muscor., p. 108. Bryol. Brit., p. 307, tab. 16. Rabenhor., Bryothec. Europ., No. 257. Dicranum adiantoïdes, Turner, Musc. Hib., p. 57. Hook. and Tayl., Muscol. Brit., Ed. 2, p. 90.

Hab. Wet rocks, banks, and pastures. Very common.

2. *F. decipiens* (De Notr., Briol. Ital., p. 479. F. rupestris, Wils., MS. Rabenhor., Bryothec. Europ., No. 825.

Hab. Moist rocky banks. At Muckross, Killarney, where it was pointed out to me by the late W. Wilson in 1866; Cromagloun, G. E. Hunt.

3. *F. taxifolius* (Hedw.). Sp. Musc., tab. 39. Bryol. Europ., vol. I. Monogr., p. 9, tab. 104. Schimp., Synops. Muscor., p. 108. Bryol. Brit., p. 308, tab. 16. Rabenhor., Bryothec. Europ., No. 64. Dicranum taxifolium, Swartz, Musc. Suec., p. 31. Hook. and Taylor, Muscol. Brit., Ed. 2, p. 91.

Hab. Moist shady banks, and pasture fields. Frequent.

4. *F. tamarindifolius* (Turner). Musc. Hib., p. 55. Bryol. Brit., p. 308, tab. 53.

Hab. Moist banks and fallow fields, The only Irish habitat recorded for this minute moss is Cullen's-wood, near Dublin, where Dr. Whitley Stokes collected it, as mentioned by Turner, in his Muscologiæ Hibernicæ Spicilegium, p. 55 (1804).

5. *F. exilis* (Hedw.). Sp. Muscor., p. 152, tab. 38. Bryol. Brit., p. 302, tab. 53. Dicranum bryoides, β minus, Turner, Musc. Hib., p. 53.

Hab. Shady banks in woods. Dr. Scott is given as the authority for the occurrence of this moss in Ireland by Wilson, in Bryol. Brit., but without mention of any special locality.

. *F. viridulus* (Linn.). Wilson, Bryol. Brit., p. 303. tab. 53. F. incurvis, Br. et Schimp., Bryol. Europ., vol. I. Monogr., p. 6, tab. 99. Dicranum viridulum, Swartz.

Hab. Shady moist banks. Wet banks at Howth, D. Orr.

7. *F. bryoides* (Hedw.). St. Crypt., p. 3, tab. 9. Bryol. Brit., p. 304, tab. 16. Bryol. Europ., vol. I. Monogr., p. 8, tab. 101. Schimp., Synops. Muscor., p. 103. Rabenhor., Bryothec. Europ., No. 727. Dicranum bryoides. Engl. Bot., tab. 625. Hook. and Tayl., Muscol. Brit., Ed. 2, p. 88.

Hab. Shady banks and moist fields. Frequent and varying much in size and appearance in different localities.

8. *F. osmundoides* (Hedw.). Sp. Musc., tab. 40. Bryol. Brit., p. 305, tab. 16. Bryol. Europ., vol. I., Monogr., p. 8, tab. 103. Schimp., Synops. Muscor., p. 106. Dicranum osmundoides, Swartz., Musc. Suec., p. 86, tab. 2, f. 4. Engl. Bot., tab. 1662.

Hab. Wet rocks in subalpine parts of the country, very variable in size and appearance, according to locality. On wet rocks at Cromagloun, the stems of this moss grow to nearly 9 inches long, and bear fruit freely. Very luxuriant on Benbulben, Sligo.

9. *F. polyphyllus* (Wils.). Bryol. Brit., p. 306, tab. 53. Bryol. Europ., Suppl., tab. 3.

Hab. On moist shady rocks. I have collected it in good condition by the side of a stream between the Upper Hotel at Glengarriff and the sea; Glengarriff, Wilson; also found there by George Hunt.

Tribe 16. POLYTRICHEÆ.

72. CATHARINEA. Ehrh.

Calyptra narrowly cuculliform, slightly hairy, or smooth and only scabrous at the apex. Capsule oblong or roundish, pedicellate; lid turgid, hemispherical at base, attenuate-mucronate or rostellate at apex. Peristome single, of 32 equidistant teeth, which are ligulate or linear, obtuse, confluent at the base, and adhering by their summits to the margin of the disc-like apex of the columella. Sporangium contiguous to the walls of the capsule. Leaves spreading equally, from a slightly sheathing base, ligulate or elongate, costate, the percurrent costa lamellated on its upper surface; areolation small and roundish. Inflorescence dioicous; male flowers rosaceous.

1. *C. undulata* (Web. et Mohr). Bot. Taschenb., 216. Briol. Ital., p. 343. Atrichum undulatum, P. Beauv.—Rabenhor., Bryothec. Europ., No. 282. Wilson, Bryol. Brit., p. 203, tab. 10. Polytrichum undulatum, Hedw. Stirp. 1, p. 43, tab. 16–17. Hook. and Tayl., Muscol. Brit., Ed. 2, p. 43.

Hab. Damp shady places among grass and about the roots of trees. Very common throughout Ireland.

73. Oligotrichum. De Cand.

Calyptra cucullate, splitting longitudinally, partially hairy or papillose at apex. Capsule long pedicellate, ovate-oblong; lid shortly rostellate. Peristome as in Catharinea, from which this genus hardly differs, except in the more campanulate calyptra, which is thinly clothed with long hairs, and the more fleshy, nerved leaves, with their nerves closely lamellated on the upper surface.

1. *O. hercynicum* (De Cand.). Flor. Gallic. Bryol. Brit., p. 205, tab. 10. Bryol. Europ., vol. iv. Monogr., p. 4, tab. 413. Schimp., Synops. Muscor., p. 436. Briol. Ital., p. 341. Rabenhor., Bryothec., Europ., No. 144. Atrichum hercynicum, P. Beauv. Polytrichum hercynicum, Hedw. St. Cr., 1, tab. 15. Smith, Engl. Bot., tab. 1219. Hook. and Tayl., Muscol. Brit., Ed. 2, p. 44.

Hab. Banks where the soil is bare in mountainous situations. Nephin mountain, Mayo, Dr. Dickie (1857), also Donegal. Lugnaquillia mountain, Wicklow, and between Woodenbridge and Arklow.

74. Pogonatum. Bridel.

Calyptra cuculliform, small, deeply cleft, submembranaceous, densely covered with long fulvous hairs. Capsule on long pedicel, oblong, or nearly hemispherical, not angulate, erect or inclined; lid rostellate from a convex base. Peristome as in the two preceding genera. Columella winged. Stems simple or branched, growing from underground rhizomes. Leaves rather rigid, spreading regularly from a sheathing base, costate, the rib broad and covered on upper surface with numerous lamellæ. Inflorescence dioicous; male flowers discoid.

Diagnosis of Species.

a. Stems elongated, branched.

Leaves elongate, patent, subulate-lanceolate, sheathing at base, serrate; keel spinulose at back; capsule with an apophysis, . 1. P. alpinum.

Stems elongated, branched, leaves erect-patent, lanceolate ; capsule without an apophysis, ... 2. P. URNIGERUM.

aa. Stems not branched at apex.

Stem short, slightly branched, leaves firm, sheathing at the base, lanceolate, serrate at apex; columella cylindrical, not winged, ... 3. P. SUBROTUNDUM.

Stems rather short; leaves linear-lanceolate, obtuse, serrate at the margins and back, capsule cylindrical ; columella winged, 4. P. NANUM.

1. *P. alpinum* (Rohl.). Deutschl. Fl., Ed. 3, p. 59. Bryol. Europ., vol. IV. Monogr., p. 9, tab. 418. Bryol. Brit., p. 207, tab. 11, fig. *a*. Engl. Bot., tab. 1905. Muscol. Brit., Ed. 2, p. 48. Rabenhor., Bryothec. Europ., No. 284. Polytrichum alpinum, Linn., Sp. Pl., p. 1109.

Hab. Fissures of rocks, on high mountains. Brandon, Kerry; Lugnaquillia, Wicklow; Sawel, Derry.

2. *P. urnigerum* (Bridel). Bryol. Univ. 2, p. 124. Bryol. Europ., vol. IV. Monogr., p. 8, tab. 417. Engl. Bot., tab. 1218. Bryol. Brit., p. 207, tab. 11, fig. *b*. Polytrichum urnigerum, Linn., Sp. Pl., p. 1109.

Hab. Moist banks, in mountainous parts of the country. Glenmalur, Wicklow; Galtee-more, Tipperary; Brandon, Kerry, &c. Not unfrequent.

3. *P. subrotundum* (Lindberg), in Hartm. Skand. Fl., Ed. 2, p. 44. Bryol. Europ., vol. IV. Monogr., p. 5, tab. 7. Bryol. Brit., p. 206, tab. 11, fig. *c*. Engl. Bot., tab. 1624 et 1625. Polytrichum subrotundum. Huds. Fl. Angl., Ed. 1, p. 400. Turner, Musc. Hib., p. 89.

Hab. Banks, tops of earthy mounds and ditches. Howth, Dublin; Lough Bray, Wicklow; Nephin, Mayo; Tor Head, Antrim, &c.

4. *P. nanum* (Weiss). Pl. Crypt. Fl. Gött., p. 173. Bryol. Europ., vol. IV. Monogr., p. 5, tab. 8. Engl. Bot., tab. 1649 and 1939. Bryol. Brit., tab. 11, fig. *d*. Polytrichum subrotundum, var *β*. Huds. Fl. Angl., Ed. 1, p. 400. P. aloides, Hedw., Stirp. Crypt. 1, p. 37. P. Dicksoni, Turn., Musc. Hib., p. 90.

Hab. Damp banks and rocky places in hilly parts of the country, and by the sides of streamlets among the mountains, frequent.

75. Polytrichum. Bridel.

Calyptra as in Pogonatum. Capsule 4, 5, or 6-angled, with a discoid apophysis. Peristome single, of 64—rarely of 32 teeth. Otherwise similar to Pogonatum in habit of growth, but the plant is much larger.

Diagnosis of Species.

a. Capsule with four angles.

Stems elongated; leaves patent, linear-subulate, recurved, serrated at margin and on the back; capsule with apophysis, 1. P. COMMUNE.

Stems simple or branched; leaves lanceolate-subulate, acuminate, subserrate, their margins involute; capsule with apophysis, ... 2. P. JUNIPERINUM.

Stems loosely cæspitose; leaves lanceolate-subulate, terminating in a diaphanous hair-like point, their margins involute, 3. P. PILIFERUM.

aa. Capsule with six angles.

Stems tufted; leaves broadly subulate or linear-lanceolate, shortly cuspidate at apex, serrate; capsule ovate or round, obscurely apophysate, . . . 4. P. GRACILE.

Stems elongated; leaves linear-lanceolate, sharply serrated, sheathing at base; capsule 5 to 6-angled, pale brown; lid conic-rostrate, . , . . . 5. P. ATTENUATUM.

1. P. *commune* (Linn.). Sp. Pl. 1, p. 1100. Turner, Musc. Hib., p. 80. Engl. Bot., tab. 1197. Bryol. Brit., p. 211, tab. 10.

Hab. Marshy woods, moors, &c. The largest of all our mosses, and one of the most abundant, varying much in habit and appearance, according to the places where it grows.

2. *P. juniperinum* (Willd.). Fl. Berol. Prodr., p. 305. Bryol. Brit., p. 213, tab. 10, fig. f. Bryol. Europ., vol. IV. Monogr., p. 12, tab. 423. Schimp., Synops. Muscor., p. 447. Muscol. Brit., Ed. 2, p. 45, tab. 10. Rabenhor., Bryothec. Europ., No. 810.

Hab. Heathy places, tops of turf walls, &c. Common. The variety *β strictum*, P. strictum, Menzies, in Linn. Soc. Trans., vol. IV., tab. 5, fig. 7, and var. *γ alpestre*, P. alpestre, Schwægr., Suppl., tab. 97, occur occasionally, the latter in elevated situations.

3. *P. piliferum*, Schreb., Spicil. Fl. Lips., p. 74. Bryol. Brit., p. 213, tab. 10. Bryol. Europ., vol. IV. Monogr., p. 11, tab. 422. Schimp., Synops. Muscor., p. 446. Turner, Musc. Hib., p. 82. Muscol. Brit., Ed. 2, p. 44.

Hab. Tops of turf walls, dry heaths, and moory places. Very common, and conspicuous by the purple calyptra.

4. *P. gracile* (Dicks.). Menzies, in Linn. Soc. Trans. vol. IV., p. 73. Bryol. Brit., p. 211, tab. 46. Bryol. Europ., vol. IV. Monogr., p. 10, tab. 421. Schimp., Synops. Muscor., p. 444. Rabenhor., Bryothec. Europ., No. 122. Engl. Bot., tab. 1827.

Hab. Turf bogs, &c. Common. It is often passed over as a weak state of P. commune, which it resembles.

5. *P. attenuatum* (Menzies), in Linn. Soc. Trans., vol. IV., p. 72. Lindberg, "Observationes de formis præsertim Europæis Polytrichoidearum" (Helsingfors, 1868). P. formosum, Hedw. Sp. Musc., p. 92. Bryol. Brit., p. 210, tab. 46. Rabenhor., Bryothec. Europ., No. 118. P. commune, var. *β*, Hook. and Taylor, Muscol. Brit., Ed. 2, p. 47.

Hab. Woods and banks in upland districts. Kylemore, Galway, is the only place where I have collected specimens. Powerscourt, Dr. Whitley Stokes, in Turner's Musc. Hib.

Tribe. 17. BUXBAUMIEÆ.

76. BUXBAUMIA. Haller.

Calyptra small, fugacious, cylindrical-campanulate. Capsule large, apophysate, inclined or oblique, flat above, and gibbous underneath, pedicel rough; lid small, sub-conic. Peristome double, the exterior united with the annulus, of 16 linear moniliform papillose teeth; interior a pale conically-plaited membrane. Leaves few and small, with large oblong areolæ. Inflorescence dioicous; male flowers gemmiform.

1. *B. aphylla* (Haller). Enum. Meth. Helv.—Bryol. Brit., p. 199, tab. 22. Bryol. Europ., vol. IV. Monogr., p. 5, tab. 427. Rabenhor., Bryothec. Europ., No. 110. Turner, Muscol. Hib., p. 104. Wade, Plantæ Rariores, p. 97, *cum icone.*

Hab. Rocks near Killarney (Dr. Wade), Muscol. Hib. "On decayed leaves, impacted with earth, in a shady situation to the south of Purple Mountain, Killarney, in its capsular state in July;" Wade, in Plant. Rar. p. 97; reprinted from Dublin Society Transactions, vol. IV. (1804). This is all that is known of its occurrence in Ireland.

77. Diphyscium. Weber et Mohr.

Calyptra small, mitriform, membranaceous, sharply conic. Capsule large, ovate-oblique, gibbous, immersed; lid conical, acuminate. Peristome single, of 16 rudimentary teeth, incrassated at the angles, cohering into a plicate cone; annulus simple, imperfect, deciduous. Leaves lingulate, spreading, thick, and rather succulent, costate, ciliated towards the apex; areolation dense and opaque. Inflorescence dioicous; male flowers gemmiform.

1. *D. foliosum* (Web. et Mohr). Bot. Taschenb., p. 377, tab. 11, fig. 4. Bryol. Brit., p. 201, tab. 8. Bryol. Europ., vol. IV. Monogr., p. 3, tab. 428. Schimp., Synops. Muscor., p. 451. Muscol. Brit., Ed. 2, p. 32. Rabenhor., Bryothec. Europ., No. 112.

Hab. Moist banks near Dunkerron, Taylor, in Fl. Hib.; roadside near Maam Hotel, Connemara, and on most of the mountains in that neighbourhood. South-west and west of Ireland.

Tribe 18. SPHAGNEÆ.

78. Sphagnum. Dillenius.

Calyptra irregularly rupturing in the middle, covering nearly all the ripe capsule, the lower portion of the ruptured calyptra persistent. Capsule sub-globose, sessile on the pedicellate vaginula; lid plane-convex. Peristome wanting. Leaves five-ranked, those on the stem differing from the branch-leaves, both in form and arrangement; stem-leaves broadly ovate, linear-lanceolate, concave, nerveless; in most cases beautifully reticulated, composed of two kinds of cellules, the one lined with spiral or annular filaments, and perforated; the other smaller, linear, without pores, and filled with chlorophyll, forming the angular serpentine network of the leaf. Inflorescence monoicous or dioicous, antheridia roundish and pedicellate, placed singly in the axils of the perigonial leaves at the clavate extremities of short branches.

Soft pale-coloured plants, flaccid when moist, unlike the typical mosses, and often growing in immense masses on wet bogs.

For full descriptions of the histology of this singular tribe, see Dr. Schimper's Monograph, "Entwicklungs-Geschichte d. Torfmoose" (1858). Also, papers "On bog mosses," published by Dr. Braithwaite, in the "Monthly Microscopical Journal," vol. VI. (1871). Louis Piré "Les Sphaignes de la Flore de Belgique," in Soc. Roy. Bot. Belg. Bulletins, tom. VI., No. 3 (1867). The genus Sphagnum is now kept apart from other mosses by most authors, and placed as an intermediate group between Mosses and Hepaticæ The Sphagna differ from other mosses chiefly in the following points:—When vegetating, they do not produce the usual confervoid prothallium of typical mosses, but a lobed foliaceous prothallus, resembling that of frondose Hepaticæ. The main stems also are unlike those of mosses in having three distinct layers, viz.—first, a kind of medulla of long cylindrical cells, next, a kind of mesophleum of prosenchymatous cells, and outside a sort of bark-layer or stratum of thin-walled cells, larger than the others. The male flowers also differ in their arrangement, and in form; the pedicellate antheridia are like those of Hepaticæ. The female flowers present other distinctions, which have already been noticed in the general characters of the tribe.

Diagnosis of Species.

a. Cortical cells of branches lined with spiral fibres.

Stem-leaves lingulate-spathulate, blunt at apex; branch-leaves broadly ovate, cucullate at apex. Dioicous, . . . 1. S. CYMBIFOLIUM.

aa. Cortical cells of branches without spiral fibres.

Hyaline cells of stems not fibrillose.

Stem-leaves obovate, obtuse, much fringed at the apex, hyaline cells large; branch-leaves ovate-lanceolate, acuminate. Monoicous, ... 2. S. FIMBRIATUM.

Stem-leaves very obtuse at the apex; branch-leaves ovate-lanceolate, acuminate. Dioicous, ... 3. S. GIRGENSOHNII.

Stem-leaves ovate, obtuse, with irregularly shaped hyaline cells; branch-leaves elliptic, obtuse, of a purplish-red colour. Dioicous, ... 4. S. RUBELLUM.

Stem-leaves ovate, erect, with two small teeth at the apex; branch-leaves spreading, ovate-lanceolate, acuminate. Monoicous, ... 5. S. CUSPIDATUM.

Stem-leaves obtuse, slightly fringed at the apex; branch-leaves recurved and squarrose. Dioicous, ... 6. S. SQUARROSUM.

aaa. Hyaline cells on upper half of cauline leaves fibrillose, those of lower half mostly without fibres.

Stem-leaves small, ovate, more or less auricled at base; branch-leaves elliptic, concave, their margins involute; more or less secund. Dioicous, . . . 7. S. SUBSECUNDUM.

Stem-leaves ovate, erect, toothed at apex; branch-leaves ovate-lanceolate, acute. Monoicous, ... 8. S. ACUTIFOLIUM.

Stem slender and fragile, with short branches, on which, among the leaves, are placed flask-shaped utricles, with recurved points, ... 9. S. TENELLUM.

1. *S. cymbifolium* (Ehrhart). Lindberg, Revis. Crit. Ic. Fl. Dan., p. 8 (1871). Braithwaite, in "Monthly Microscopical Journal," VII., p. 55, pl. ix. (1872). S. latifolium, Turner, Musc. Hib., p. 5. S. obtusifolium, Muscol. Brit., p. 3., tab. 4. Var. *β*, *S. compactum*, Bridel, Bryol. Univ. 1, p. 16, *partim.*

Hab. Bogs and marshes. Frequent. Var. *β*, at Kylemore Galway.

2. *S. fimbriatum* (Wilson). Bryol. Brit., p. 21, tab. 60. Piré, l. c., No. 3.

Hab. Marshes and bogs. At Lough Bray, Wicklow. Apparently rare in Ireland.

3. *S. Girgensohnii* (Russow). Piré, "Les Sphaignes de la Flore de Belgique," in Soc. Roy. de Botanique de Belgique Bulletins, tom. VI. (1867), No. 4, fig. 7. Stem leaf—Rabenhor., Bryothec. Europ., No. 801.

Hab. Wet banks. Glenmalur, Wicklow. Apparently rare.

4. *S. rubellum* (Wilson). Bryol. Brit., p. 19, tab. 60. Schimp., Torfmoose, p. 70, tab. 20. Piré, l. c. No. 5. Braithwaite, in "Monthly Microscopical Journal," VIII., p. 3, pl. xxii. (1872). Lindberg, Torfmoose, No. 12 (1862).

Hab. Wet banks and bogs. Not unfrequent in Ireland. This handsome species was collected many years ago by Templeton in the north, and by Miss Hutchins in the south, though not described as a species when sent to Dawson Turner.

5. *S. cuspidatum* (Ehrhart). Wilson, Bryol. Brit., p. 21, tab. 61. Engl.Bot., tab. 2092. Piré, l. c. No. 6.

Hab. Turf bogs, &c. Brandon, Kerry; Kylemore, Galway, &c.

6. *S. squarrosum* (Persoon). Wilson, Bryol. Brit., p. 23, tab. 4. Muscol. Brit, Ed. 2, tab. 4. Piré, l. c. No. 2. Rabenhor., Bryothec. Europ., No. 212.

Hab. Bogs and marshes. Frequent, and generally distributed.

7. *S. subsecundum* (Nees Von Esenbeck). Sturm, Deutschl. Flor. Crypt., Fasc. 17 (1820). Piré, l. c. No. 9. Braithwaite, in "Monthly Microscopical Journal," IX., p. 12, pl. iii. & IV., (1873). S. contortum, var. β, secundum, Wilson, Bryol. Brit., p. 22, tab. 60.

Hab. Wet banks and turf bogs, Lough Bray, Wicklow; Howth, Dublin, D. Orr; Connemara, Galway; also Antrim, Cork, &c.

Var. β, *contortum*, S. contortum, Schultz.—Wilson, Bryol. Brit., p. 22, tab. 60; has been collected at Howth, Dublin, and Lough Bray, Wicklow.

Var. δ, *auriculatum*, S. auriculatum, Schimp., Torfmoose, p. 77, tab. 24. Piré, l. c. fig. 9: was collected by Dr. Carrington on wet banks among heath near Killarney.

8. *S. acutifolium* (Ehrhart). Wilson, Bryol. Brit., p. 20, tab. 4. Piré, l. c. No. 8. Eng. Bot., tab. 1406.

Hab. Wet bogs and marshes. Frequent, and generally distributed.

9. *S. tenellum* (Ehrhart). Bridel, Bryol. Univ. 1, p. 4. Lindberg, Torfmoose, No. 13. Braithwaite, l. c. VII., p. 256. pl. xix. (1872). S. molluscum, Bridel, Bryol. Univ. 1, p. 753 (1826). Wilson, Bryol. Brit., p. 19, tab. 60. Schimper, Torfmoose, p. 71, tab. 21. Piré, l. c. fig. 9.

Hab. Wet woods and damp heaths. Glenmalur, Wicklow; Brandon, Kerry. Rare in Ireland.

Tribe 19. ANDREÆACEÆ.

79. Andreæa. Ehrhart.

Calyptra slender, membranaceous, mitriform, closely covering the capsule, and fugacious. Capsule oblong-oval, erect, sessile, or spuriously pedicellate, on the elongated perichætium; dehiscing by four longitudinal fissures at the sides, into four segments, which are united at the summit by the persistent apex or lid. Leaves imbricated, mostly of a brownish or blackish colour, ovate, ovate-lanceolate, or subulate, with or without nerves; areolation dense on upper portion, larger and more pellucid at the base. Inflorescence monoicous or dioicous.

This tribe differs from the typical mosses fully as much as the Sphagneæ. In both the calyptra is severed in the centre by the growth of the ripening capsule, and not by the elongating fruit-stalk. The capsule also is in structure allied to that of some Hepaticæ, except that the four valves are held together by the persistent lid.

Diagnosis of Species.

a. Leaves nerveless.

Stems elongated, fastigiate; leaves spathulate, ovate-acuminate, concave, contracted below the middle, . . . 1. A. alpina.

Stems short, branches fastigiate; leaves oblong-lanceolate, the upper falcate, secund, rather obtuse, papillose, . . 2. A. petrophila.

aa. Leaves nerved.

Stems very short; leaves lanceolate-subulate, falcate, secund, loosely imbricated, nerved to the apex, ... 3. A. rupestris.

Stems prostrate, fragile, growing in rather dense tufts; leaves crowded, falcate, secund, ovate-subulate; strongly nerved, nerve filling the whole upper portion of the leaf, ... 4. A. crassinervia.

1. *A. alpina* (Dill.). Wilson, Bryol. Brit., p. 11, tab. 8. Engl. Bot., tab. 1278. Rabenhor., Bryothec. Europ., No. 851.

Hab. Mountain rocks. Abundant on Brandon, Kerry; Upper Lough Bray, Wicklow; Connemara, Galway.

2. *A. petrophila* (Ehrhart). Br. et Schimp., Bryol. Europ., vol. VI. Monogr., p. 13, tab. 623, 625. A. rupestris, Bryol. Brit., p. 12, tab. 8. Engl. Bot., tab. 1277. Rabenhor., Bryothec. Europ., No. 51.

Hab. Mountain rocks. Lugnaquillia, Wicklow; Connemara, Galway. Probably not rare.

3. *A. rupestris* (Turner). Muscol. Hib., p. 14. Br. et Schimp., Bryol. Europ., vol. VI. Monogr., p. 21, tab. 631, 632. Schimp., Synops. Muscor., p. 667. A. Rothii., Bryol. Brit., p. 12, tab. 8. Hook. and Taylor, Muscol. Brit., p. 2, tab. 8.

Hab. Mountain rocks. Common, and generally distributed.

4. *A. crassinervia* (Bruch). Braithwaite, in Seemann's "Journal of Botany," vol. VIII., p. 95 (1870).

Hab. Mountain rocks. Above Upper Lough Bray. I have not been able to understand this so-called species sufficiently to separate it with any confidence from A. rupestris. Specimens which I sent to the late Mr. Wilson were so named by him, noted however as—"Too near A. rupestris."

I have specimens sent to me, which were collected in Ireland by Mr G. E. Hunt, and marked A. falcata, Schimper, which they probably are; but I think it better not to add this as a species at present to our list.

ADDITIONAL SPECIES.

To follow No. 2, p. 346.

Dicranella Schreberi (Hedw.). Sp. Musc., tab. 33. Dicranum Schreberi, Bryol. Europ., vol. I. Monogr., p. 18, tab. 53. Bryol. Brit., p. 69, tab. 39. Angstrœmia Schreberi, C. Müller, Synops. Musc. 1, p. 438.

Hab. Moist clayey banks. Near Dunsink, Dublin, D. Orr, October, 1869. Not hitherto observed elsewhere in Ireland.

To follow No. 1, p. 369.

Weissia mucronata (Bruch et Schimp.). Bryol. Europ. vol. I. Monogr., p. 7, tab. 23. W. apiculata, Nees et Hornsch. Bryol. Germ., tab. 26. Bryol. Brit., p. 47, tab. 38.

Hab. Damp arable ground. Fields near Rathmullen, Donegal, Captain F. W. Hutton (1865). The only known locality for this moss in Ireland.

ADDITIONAL SPECIES.

(*Continued*).

To follow No. 3, p. 373.

Trichostomum littorale (Mitten). Seemann's "Journal of Botany," vol. VI., p. 99 (1868), tab. 77.

Hab. Cliffs near the sea. "Ireland, Drummond," *fide* Mitten.

To follow No. 2, p. 427.

Pylaisia polyantha (Hedw.). Pylaisia polyantha, Br. et Schimp., Bryol. Europ., vol. v. Monogr., p. 3, tab. 455. Hypnum polyanthos (Hook.), Power, in Flor. Cork, p. 91.

Hab. On trees. Great Island, in Cork Harbour (Dr. Scott). Flor. Cork. Muckross demesne, Killarney, Dr. Carrington.

To follow No. 27, p. 439.

H. (*Rhynchostegium*) *hians* (Hedw.). Sp. Musc., p. 272, tab. 70, figs. 11–14.

Hab. Rocky sides of streams. Ballinascorney and Hillbrook, Dublin, D. Orr (1858). The specimens collected by Mr. Orr agree well with Hedwig's figure, and have been verified by the late Messrs. Wilson and Hunt. This is the plant given erroneously as Rhynchostegium strigosum on p. 438.

To follow No. 58, p. 449.

Hypnum crista-castrensis (Linn.). Sp. Pl. 1591. Bryol. Brit., p. 395, tab. 27. Bryol. Europ., vol. VI. Monogr., p. 30, tab. 599.

Hab. Woods in subalpine districts. Colin Glen, near Belfast, D. Orr. Not found in Ireland by any other person.

In conclusion, I gratefully acknowledge the valuable assistance which I have constantly received from the late Mr. W. Wilson, whose friendship it was my privilege to enjoy for many years, and who, at all times, was most willing to give me his opinion in any cases of difficulty. I have also been under similar obligations to the late Mr. G. E. Hunt, of Manchester. My friend and colleague in the "Cybele Hibernica," Mr. A. G. More, has kindly aided me in revising the proof-sheets for the press.

LIST OF BOOKS AND PAPERS RELATING TO THE MOSSES OF IRELAND.

DAWSON TURNER—"Muscologiæ Hibernicæ Spicilegium" (1804). This book includes 14 species, which were afterwards omitted in "Flora Hibernica," viz.:—Dicranum rufescens, D. fuscescens Orthotrichum pumilum, Bryum bicolor. (erythrocarpum), Bryum marginatum (Mnium serratum), Mnium cuspidatum, Hypnum denticulatum β., H. Teesdalii, H. revolvens, H. Swartzii, Fissidens exilis, Polytrichum, subrotundum P. attenuatum and Buxbaumia aphylla, some of which were considered by Taylor as varieties.

THOMAS TAYLOR, M.D.—"Flora Hibernica," part II., containing Musci Hepaticæ and Lichens (1836). In this book Dr. Taylor enumerates and describes 229 species as Irish, which, with 14 in Dawson Turner's work, bring the Moss Flora up to 243 species.

THOMAS TAYLOR, M.D.—"On two new Species of British Mosses," Bot. Soc. Edin. Transactions, vol. II., p. 1 (1844). Bryum (Didymodon) recurvifolium, and Trichostomum saxatile (Racomitrium heterostichum, var, β); both found in Ireland.

THOMAS POWER, M. D.—"Contributions towards the Fauna and Flora of Cork," part II., Botany (1845), adds Gymnostomum Wilsoni, Polytrichum hercynicum, Bryum pyriforme, Bryum Tozeri, Hypnum demissum (flavescens), H. (Pylaisia) polyanthos.

WM. WILSON—"Bryologia Britannica" (1855). In this work the author adds to the Irish list 30 species, viz.:—Campylopus setifolius, Dicranodontium longirostre, Grimmia patens, G. leucophœa, Tortula ambigua, T. oblongifolia, (Vahliana) Gymnostomum ovatum β, (Tortula lamellata) Anœctangium Hornschuchianum, (Tortula hibernica) Tortula squarrosa Encalypta ciliata, Orthotrichum tenellum, O. Ludwigii, O Drummondii, Bartramidula Wilsoni, Bartramia rigida, Bryum pallescens, Hedwigidium imberbe, Neckera pennata, Plagiothecium elegans, Hypnum depressum, H. polygamum, H. striatulum, H. pumilum, H. subsphœrocarpum, H. ochraceum, Fissidens tamarindifolus, F. osmundoides, F. polyphyllus, Sphagnum rubellum. Didymodon luridus.

ISAAC CARROLL—"New or scarce Irish Mosses," Phytologist, 2nd series, vol. I., p. 236 (1856)—adds 19 species:—Sphagnum contortum, Dicranum Blyttii, Pottia crinita, Trichostomum flexicaule, Tortula Hornschuchiana, T. lævipila, Grimmia orbicularis, Bryum uliginosum, B. cernuum, B. inclinatum, (pendulum) B. intermedium, B. pseudo triquetrum, B. Donianum, Physcomitrium fasciculare, Leskea subrufa, Hypnum rivulare, H. speciosum, H. circinatum, H. chrysophyllum, — Hypnum salebrosum, and H. lutescens are in "Flora Hibernica," H. pratense in Wilson's "Bryologia Britannica."

D. Moore—"Observations on the Mosses of Ireland," Royal Dublin Society's Journal, vol. I., p. 100 (1858), and reprinted as "Irish Mosses" in Phytologist, 2nd series, vol. II., p. 37 (1857)—adds 16 species:—Phascum bryoides, Dicranum majus, Rhabdoweissia denticulata, Tortula aloides, T. latifolia, T. papillosa, Racomitrium protensum, Orthotrichum rupestre, O. phyllanthum, O. crispulum, Bryum atropurpureum, B. torquescens, Hypnum illecebrum, H. lycopodioides, H. crista-castrensis, Leskea rufescens. —Leskea Sprucei remains doubtful.

J. H. Davies—"Muscologia Hibernica," Phytologist, 2nd series, vol. II., p. 229 (1857)—adds Orthotrichum Lyellii, and Bryum capillare β obconicum.

D. Moore—"On a Metamorphosed State of Bryum sanguineum, (erythrocarpum) and on the discovery of some additional Species to the Irish Flora," Nat. Hist. Review, vol. v., p. 129 (1858)—adds Grimmia Schultzii, and Bryum Warneum.

D. Moore—"Observations, also Notices of some new Species to the Irish Flora, &c.," Nat. Hist. Review, vol. VI., p. 155 (1859)—adds Hypnum megapolitanum.

J. H. Davies—"Notes on the Muscology of Colin Glen," Phytologist, 2nd series, vol. v., p. 26 (1861).

J. B. Wood, M.D.—"Supplemental Notes on Orthotrichum anomalum," Phytologist, 2nd series, vol. v., p. 26 (1861)—adds Orthotrichum Sturmii, and defines O. saxatile (anomalum).

D. Moore—"Contributions to the British and Irish Floras of Musci and Hepaticæ," Dublin University Zool. and Bot. Association Proceedings, vol. II., p. 80 (1863)—adds Campylopus polytrichoides (introflexus) Bryum acuminatum and Hypnum Kneiffii.

B. Carrington—"Gleanings among the Irish Cryptogams," Bot. Soc. of Edinburgh Trans., vol. VII., p. 379 (1863)—adds Orthotrichum (Ulota) calvescens.

D. Moore, Ph. D.—"On some Mosses new to the British Flora," Dublin Nat. Hist. Soc. Proceedings, vol. IV., p. 290 (1865)—adds Campylopus intermedius (alpinus), C. Schwarzii, Barbula recurvifolia, Gymnostomum tortile, Weissia mucronata.

D. Moore, Ph. D.—"Addenda to the Musci and Hepaticæ of Flora Hibernica, &c.," Dublin Nat. Hist. Soc. Proceedings, vol. v., p. 89 (1866)—adds Hypnum dilatatum (eugyrium), Trichostomum (Tortula) sinuosum, Grimmia ovata, Phascum cohærens.

D. MOORE, Ph. D.—"Note of some Species of Mosses new to the Irish Flora," Dublin Nat. Hist. Soc. Proceedings, vol. v., p. 158 (1867)—adds Tortula Mulleri (princeps), Mnium affine, and Cylindrothecium concinnum.

W. MITTEN—"A few Notes on some British Mosses allied to Tortula Fallax," Seemann's "Journal of Botany," vol. v., p. 324 (1867) —adds Tortula spadicea and defines T. Hibernica. (Anœctangium Hornschuchianum, Bryol. Brit.)—Grimmia gigantea, mentioned in this paper as having been found in Ireland, proves to be Tortula reflexa.

D. MOORE, Ph. D.—"Addenda to British and Irish Muscology," Dublin Nat. Hist. Soc. Proceedings, vol. v., p. 190 (1868).

W. MITTEN—"New or rare British Mosses," Seemann's Journal of Botany, vol. VI., p. 97 (1868)—adds Trichostomum littorale.

G. E. HUNT—"On Mosses new to Britain," Manchester Literary and Philosophical Society Transactions, vol. IX., p. 19 (1871)—adds Entosthodon minimus (Splachnobryum Wrightii).

R. BRAITHWAITE, M. D.—"Recent Additions to our Moss Flora," Seemann's "Journal of Botany," vol. IX., p. 289 (1871)—adds Trichostomum flavovirens.

R. BRAITHWAITE, M. D.—"Recent Additions to our Moss Flora," Seemann's "Journal of Botany," vol. I., p. 193 (1872)—adds Grimmia robusta.

The species added in the present Synopsis amount to 36, viz.:— Dicranella Grevilleana, Campylopus brevipilus, D. Hartmanni, Schistidium confertum, Gymnostomum calcareum, Didymodon flexifolius, Tortula reflexa, T. intermedia, T, fragilis, Orthotrichum stramineum O. pallens, O. fastigiatum, O. Bruchii, Zygodon Mougeoti, Ephemerum cohærens, Physcomitrium ericetorum, Bartramia calcarea, Bryum polymorphum, B. annotinum, B. Wahlenbergii, B. Duvalii, Hypnum (Brachythecium) glareosum, H. (Rhynchostegium) hians, H. (Amblystegium) irriguum, H. Lindbergii, H. vernicosum, H. intermedium, H. hamulosum, Fissidens decipiens, F. viridulus, Dicranella Schreberi, Polytrichum gracile, Sphagnum fimbriatum, S. Girgensohnii, S. tenellum, Andreæa crassinervia.

This leaves 377 as the total number of Mosses at present known in Ireland, as compared with about 570 in Great Britain.

CORRIGENDA.

Page 331, line 10, *for* 140 *read* 147.
— 845, — 16, *for* CERVICULATUM, *read* CERVICULATA.
— 845, — 18, *for* SUBULATUM, *read* SUBULUTA.
— 845, — 19, *for* HETEROMALLUM, *read* HETEROMALLA.
— 845, — 20, *for* VARIUM, *read* VARIA.
— 858, — 16, *for* CONFERTA, *read* CONFERTUM.
— 886, — 22, *for* capulatum *read* cupulatum.
— 440, — 1 from bottom, *for* excurrent, *read* percurrent.
— 440, — 7 from bottom, *for* excurrent, *read* percurrent.
— 445, — 12 from top, *for* excurrent, *read* percurrent.
— 445, — 15 from top, *for* excurrent, *read* percurrent.
— 382, — 13 from bottom, *for* No. 34, *read* 135.
— 383, — 4 from top, *for* No. 294, *read* 312.
— 410, — 7, *for* Flo. Hib., *read* Musc. Hib.
— 411, — 16 from top, *for* No. 244, *read* 249.
— 427, — 7 from bottom, *for* No. 33, *read* 334.
— 427, — 11 from bottom, *for* No. 534, *read* 334.
— 438, No. 23, *for* Rhynchostegium strigosum *read* R. hians. (See p. 465).
— 440, line 12 from top, *for* No. 35, *read* 351.

INDEX.

The Genera are printed in small capitals, the Species in ordinary type, the Synonyms in italics.

XXXVIII.—A FURTHER COMMUNICATION ON OPTICAL SACCHAROMETRY, WITH SPECIAL REFERENCE TO THE SUGAR BEETS GROWN IN IRELAND IN THE YEAR 1872. BY THE PRESIDENT.

[Read to the Academy, 24th February, 1872.]

THE Author took occasion in the first place to describe to the Academy an improvement which he had effected in the construction of the Saccharometer. According to the original construction of this instrument, the tube containing the fluid under examination is made to plunge into the compensating fluid, the length of the column of this latter being determined by the position of the tube. As it is not always possible to preserve a perfect identity between the temperature of the compensating fluid and that of the surrounding air, the temperatures of the immersed and unimmersed portions of the tube are often slightly different. This unequal heating, which is necessarily communicated to the fluid contained in the tube, is found to destroy the perfect polarization of the light, which is absolutely essential to the accuracy of the experiment.

According to the improved construction, the tube containing the fluid under examination remains fixed, and the length of the column of compensating fluid is regulated by the immersion of an *empty* tube, closed at the lower end with glass, and so placed as to be *in direction* with the first tube. The unequal heating of the fluid under examination is thus avoided.

Another advantage which may be obtained from this construction is, that it renders possible an arrangement by which comparative observation of two fluids, an object of great importance in all such experiments, is greatly facilitated. Instead of a single pair of rests for the tube containing the assay, the instrument is furnished with two pairs capable of holding two tubes in a position of accurate parallelism. These rests are set in a sliding plate, thus enabling the observer by a lateral motion to bring either into the field of view, and thus to make comparative observations in very rapid succession.

Thus in the present experiment, one of these tubes is filled with the best syrup, and the other with a standard solution of cane sugar. The comparative strength of these two can be obtained with great accuracy.

The author observed that in the examination of beet syrup, at least according to the process which he had employed, it is for all practical purposes sufficient to make this one comparative experiment, calculating the quantity of sucrose in the syrup on the hypothesis that the rotation of the plane of polarization is due to this sugar alone.

The approximate truth of this supposition depends upon the facts that the grape and inverted sugars are present in very small quantities,

and that as these sugars have opposite rotatory powers, the amount of rotation produced by their presence is only the *difference* between the separate effects.

It is easy to verify the former of these suppositions by submitting the beet syrup *uninverted* to the copper test. If it be found that any appreciable amount of the copper is reduced, it will be necessary to have recourse to the more general method.

Referring more especially to the sugar beets grown in Ireland in 1872, the author said that an examination of these beets was important, because the atmospheric conditions of the past year were, at least according to the ordinarily received opinions, peculiarly unfavourable to the development of sugar. The amount, therefore, obtained from the beets of 1872 might be regarded as a minimum; unless indeed it be a mistake to suppose that hot, dry weather is essential to the sugar-producing qualities of the beet. Under either supposition the rest of the experiment has evidently an important bearing upon the question, whether the sugar beet can be profitably grown in Ireland.

The accompanying table contains the result of four specimens of sugar beet grown upon the Albert farm, Glasnevin, in the year 1872.

No. of root.	Manure used.	Water per cent.	Sugar per cent.
1.	Common Salt,	79·99	12·72
2.	Sulphate of Potash,	80·27	13.18
3.	No manure,	80·60	12·42
4.	Sulphate of Ammonia,	80·52	11·85
Mean,		80·34	12·54

If these results be compared with the results obtained by the author for the sugar beets of 1870, it will be seen that there is no diminution in the quantity of sugar. It seems probable therefore that hot dry weather is not essential to the sugar-producing qualities of the beet.

XXXIX.—Description of a Comparable Hygrometer, which Registers the Maximum and Minimum of Siccity and Humidity of the Atmosphere in the absence of an Observer, with Observations on its Employment. By M. Donovan, Esq. (With Plate XXV., Science.)

[Read April 14, 1873.]

To discover the presence and measure the quantity of invisible watery vapour contained in any volume of the atmosphere has long been a desideratum, for the attainment of which hygrometers have been invented. They are variously constructed, and generally of a material

which, by absorbing moisture, increases in weight or bulk; or in some way alters its state of physical existence. To this end, animal, vegetable, earthy, or metallic substances have been employed. The variety of the materials and contrivances is an acknowledgment of the importance attributed to the subject.

Of these different materials I have selected, as the hygroscopic medium, the string manufactured from the intestines of an animal, which being twisted and dried for the purposes of the arts, in that state arsorbs moisture from damp air, or gives it out in dry air, in both cases developing, in contrary directions, the force called Torsion, which is the agent in the instrument now to be described.

It consists of a graduated circular brass plate, two inches in diameter, supported on a pillar and foot, and carrying a perpendicular stem four or five inches long, half of which slides up and down in a tube fixed perpendicularly to the edge of the circular plate, and may be held at any required height by a clamp-screw. (See Pl. XXV., Science.)

At the top of the stem, at a right angle, is a cross-bar holding a spring to which is attached one end of the gut string, the other end being connected with a silk string: this latter, passing downward through the centre of the graduated plate and pillar, is rolled round an adjustable tightening-pin acting underneath the foot. The junction of the gut to the silk string is effected by a brass coupling joint holding a horizontal index, which, by the torsion of the gut string, points to the graduation of the plate, which it nearly touches, and indicates the degree of moisture existing in the atmosphere. But the torsion force which acts on the gut string, being not equipollent throughout, the degrees are not all of equal value. A shallow groove or channel traverses the edge of the circular plate, the use of which will appear hereafter. The circular plate shall henceforward be called the Dial: it is graduated into 100 degrees.

Such is the general appearance of this instrument, in the principle of which there is so far little originality. I must now enter into particulars relative to its parts; and first, with regard to the gut string, the most important of all. I have tried a number of such strings, amongst others the gut strings of musical instruments—such as are not covered with wire, and selected from a number of violin, harp, and guitar strings a size that answers my purpose fully. As sold in music shops, these strings sometimes contain oil; this must be removed by *gentle* rubbing with soft cotton wool; forcible stretching is to be carefully avoided, as such would destroy or greatly impair the hygroscopic power. The gut string being cut to the proper length, one end is to be connected with the end of a thin string consisting of a few fibres of floss-silk, the connexion being made by two minute conical pieces of brass, which screw together, base to base, leaving a cavity in their substance. A very small hole is drilled through the apex of each, one barely sufficient to admit the gut string, and the other the silk. The screw on one of the conical pieces is received into the other,

and between them is the horizontal index which points to the degrees on the graduated dial. The gut string is secured in its cone by a knob on its end, which cannot be drawn out of the hole. The silk string is secured in the other cone by a knot. The gut-string and silk then form one straight continuous line, held together by the little brass double cone connexion which keeps them firmly joined when the two pieces are screwed together with the index between. This is what I shall henceforward call the Compound-line: when in its place, the silk portion should be about one third of the length of the gut string, which, not including the part above the cross-bar, may be $3\frac{1}{4}$ inches long, or more if found necessary.

The compound-line is the important and acting portion of the whole instrument. The manufacturer of the gut portion, in fitting it for its uses, had twisted it while recent into several spiral convolutions; after which it was dried. When fitted in the hygrometer for use, it absorbs moisture from the atmosphere, shortens a little, untwists more or less, and its position being vertical, and having the index attached horizontally to its lower end, where it joins the silk and has the greatest freedom of motion, it turns the index round over the horizontal graduated dial, and thus indicates the degree of moisture which the atmosphere was at that time capable of imparting. This it does because the lower end is at liberty, while the upper end is confined: I say at liberty, for being rather loosely held by a few fibres of floss-silk, scarcely any obstruction is offered.

As the efficiency of the hygrometer depends on the quality of the gut string and its management, a minute description will not be deemed unnecessary. The gut string employed measured three feet, and weighed three grains and a quarter: it is I believe the thinnest string in use. The necessary length being cut off, a knob is to be formed on one end by a momentary scorching in the flame of a candle. This knob is to be softened by immersion in water to the depth of $\frac{1}{8}$ inch for half an hour. The gut being drawn through the hole in one of the brass cones, the knob will fill up its cavity; and the silk line, knotted at one end, being similarly drawn through the other cone, both cones are to be screwed together, and the compound line thus formed should be immediately transferred to the frame of the hygrometer, the tightening pin being so regulated as to cause a *slight* tension. The knob of the gut line will in a few hours become hard, and will have assumed such a position in the cavity of the cone as will permit the index to traverse the circular groove without obstruction, as if turning on an axis.

The chief points that demand attention regarding the compound line, the index and the dial, are as follows: the compound line must be central and vertical; the index and dial must be horizontal and therefore parallel. If these conditions be not accurately fulfilled, the instrument must necessarily prove a failure, as will hereafter fully appear.

As a summary:—the compound line passes from the spring at the top of the hygrometer through a very small guide-hole in the cross-bar down through the centre of the dial-plate: the silk portion passes through the pillar and through another guide-hole in the foot, where it is secured to the tightening-pin. The spring is necessary for preserving a certain tension which ought to be very slight, and barely sufficient to preserve the rectilinear direction of the compound line. If stronger, it will interfere with the twist of the gut, and give a false result on the dial.

It will always be a proof that the compound line and index are in proper condition, with regard to each other, when, on moving the index a little out of its place, it springs back beyond its previous situation, and vibrates a few times back and forward over the degree on which it is to settle; but not with much force, for that would be a proof that its tension is too great, and a false indication would be given. This vibration should be always sought as a test that the tension is sufficient to prevent the gut line from turning without carrying the index. The proper degree of tension can be obtained by the counteracting influence on each other of the spring at the top and the tightening-pin at the bottom; and both of these agents can be so antagonized that the index will revolve without touching the groove, or passing over the markers when such are used.

If the compound line and dial be not exactly at right angles, the index, in revolving, will occasionally rub the dial and obstruct the feeble torsion force acting on the distant end of the index. The success of the instrument depends mainly on the due freedom of the index, which has to fulfil another important function hereafter to be described. But the index may be free in another sense which would altogether defeat the object of the instrument: if the two inverted cones, which contain the knobs of gut and silk, be not screwed so closely as to carry the index along with them, the latter will have no effect, and indicate nothing.

It would be the perfection of the instrument if the small additional expense were incurred of gilding it, as it might then be occasionally left uncovered in the open air, even during a fall of rain or snow—occurrences of no small interest to the hygroscopist. Whether gilt or not, it will be proper to append to the instrument a glass receiver ground air-tight to a thick glass plate, in the manner of an air-pump. With these, many interesting experiments and observations may be made; and they will serve to protect the gut line, when not in use, from the action of the weather, as while under the receiver it does not obey the changes of the atmosphere. They will also protect the hygrometer from the corroding agency of damp and acid vapours, both of which would be specially injurious to the necessary polish of the groove.

The glass plate and receiver are applicable to other and more important services. It may be occasionally found necessary to expose the hygrometer to an atmosphere of extreme dryness at a time when per-

haps it has been long raining. For effecting this purpose conveniently, two or three discs of spongio-piline (a substance well known to the medical profession), of such a size as will fit in the glass receiver, are to be soaked in hot concentrated solution of chloride of calcium, and perfectly dried before a fire. These are to be kept for occasional use carefully secluded from the air: they may sometimes require to be redried.

When the effect of air of extreme siccity is required for a hygrometrical experiment, these discs are to be laid on the glass plate, covered with a disc of card-paper, the hygrometer placed on the card, and the receiver, its edge slightly greased, over all. The motion of the index will immediately retrograde through 90°, 80°, 70°, &c.

Should an atmosphere of extreme moisture be required, several discs of blotting paper, soaked in water, are to be substituted for the saturated spongio-piline: the motion of the index will be through 10°, 20°, 30°, &c.

There is a fact deserving of notice here, which, if unattended to, might lead to misconception in the management of experiments with this hygrometer. When the gut line has been dried to its apparent maximum, by means of chloride of calcium, if the receiver containing the hygrometer be immediately placed in hot summer sunshine, the index will indicate increasing dryness, to the extent of 40 or even 60 degrees. This fact might lead to a doubt of the adequacy of the chemical means made use of for absorbing moisture, but it may be explained by attributing the appearance of increased dryness to increased twisting of the gut line by heat, without any extrusion of moisture. Be this as it may, the exsiccation will give reliable results if performed in the shade. Winter sunshine has almost no effect.

The degree indicated on the dial would give but little information unless viewed in conjunction with the previous situation and movement of the index: it is therefore necessary that there should be found on the dial some assistance to memory, besides the degrees. For this purpose, I use very small spherules, which are easily moved by the index during its progress. They must be perfectly smooth and light, in order that they may roll with the slightest touch: glass is a good material, and we have markers, almost ready-made, in those small black beads used by ladies for ornamental purposes: their size should be such that 100 shall average 16 grains weight. But they have two defects; they are perforated, and are in some degree flat, and therefore will not readily roll under a weak impulse. Both defects may be remedied by the following process. If one of these beads be placed on a piece of charcoal, and a jet from a voluminous flame be thrown on it, by means of a blow-pipe, it will speedily melt, and if thoroughly melted will, by cohesion, become a nearly perfect spherule; at the same time, the hole closes. When about to be used, both the spherule and the groove must be perfectly clean.

A spherule thus obtained, if placed in the groove of the dial, will

roll round it, or obey any impulse communicated to it by the index. It will remain at some degree, and thus mark where the index stood at a particular time. Or, if a spherule be placed at each side of the index, the weather being damp, one will almost immediately begin to remove from the other, and will continue to remove until it reach the maximum of the time, or until its course be altered or stopped by some new atmospheric change: the first will show the condition of the air when the change commenced; the second the angular amount of the change.

To enable the index to move the spherule, it is provided with a pin at the end pointing downwards into the groove of the dial, but not so as to touch the groove.

The rotation of the index would inevitably sooner or later throw these light spherules out of their proper place, or off the dial altogether, but for the prevention of the shallow groove in which they are placed.

There are seasons when long continued rains render the atmosphere so loaded with moisture that the circle of the dial and its hundred degrees would prove insufficient to record its changes. The index having traversed the entire circle, it may be inquired what can it do more than go round again and again; and how is the hygroscopist to learn how often it has done so in his absence? Means are provided. Adjoining that part of the circular groove marked O or zero is a perforation in the dial wide enough to allow a spherule to pass through it. When the spherule on duty has been chased from its first position beside the zero, all round the circular groove, it drops through the perforation into the receiver underneath, and its absence from the dial indicates that one round (or 100 degrees) has been accomplished. The index proceeds on its course; and if a second spherule had been placed beside the first, as should generally be, with the index between the two, the perforation being beside both, this second spherule will now be chased like the first, and will drop through the perforation, thus indicating the completion of a second round of the dial, or 200 degrees. The index, still proceeding, will at length pass over and beyond the perforation, and thereby indicate a third circuit, or 300 degrees, which however is not otherwise marked than by the passage of the index over and beyond the perforation. Any degrees beyond this, to which the index may have arrived, short of zero, is a decimal of a fourth round. If a further account be required to be kept, two new spherules may be placed beside the index as before. More than this there is almost never occasion for, as such persistent moisture of the air is rarely experienced, without an opportunity of resetting the instrument.

When no account of consecutive rounds of the index is required to be kept, the hole for the fall through of the spherules might be inconvenient. To meet this, there is a slightly conical brass stopper fitted to the hole so exactly, its surface being made to constitute a portion of the groove, that not the least obstruction is opposed to the rolling of the spherules.

It is necessary that the position of the graduated dial-plate should be truly horizontal, as, if not, the spherules will indicate incorrectly. A wooden stand with three levelling screws would be convenient, if not indispensable.

When it is desirable to observe the hygrometrical state of the atmosphere and its changes more particularly, it will be proper to start from the natural zero, hereafter described, which point may be attained by the use of the ground glass receiver with its glass plate and discs impregnated with dry chloride of calcium. The index is to be brought to the hundredth degree by loosening the clamp-screw which confines the gut line at top, and turning the latter round until the index point correctly: the gut line being then very moderately stretched, and the clamp-screw tightened, the hygrometer is ready for use. The tightening of the clamp-screw generally removes the index a few degrees from zero, but a slight turn of the tightening-pin one way or the other will restore it to its place.

While the hygrometer is in this state, should the weather be dry, the index will not at that time change its position, for it is already at its maximum of dryness. If the weather be wet or damp, a spherule placed in the groove will be gradually pushed round, according to the numerical increase of the degrees engraved on the dial, until it fall through the perforation. Dampness and dryness alternating perhaps several times during the day, the course of the index will be as often reversed until ultimately the spherule disappear, indicating that 100 degrees have been traversed.

At any time when it is desirable to know at what rate the atmosphere is becoming more or less dry, should there be any change, a spherule may be placed, touching the index at each side; and on the return of the observer, the separation of the two will give the desired information in degrees. In such cases, it will not be necessary to bring the index previously to zero.

But an observer may then, or at any time require to know whether the index, now apparently at rest, have been advancing in dampness or receding in dryness. This is shown by a minute steel bead, attached by a flaccid fibre a quarter of an inch long to the balance-end of the index. This bead will trail after the index, and thus show the direction of the last or present movement. But for the steel bead, inspection of the hygrometer would not show, at a glance, the present state or latest change of the index. The only sufficiently flexible fibre that succeeded in my very numerous trials was a bit of the warp of the finest French cambric, washed in distilled water, and softened by beating: every other fibre tried, whether wool, cotton, or even cocoon silk, failed, being too elastic. When the steel bead is directly under the index, the weather is changing.

It is necessary here to explain what I mean by advancing in dampness or receding in dryness: the former is meant when the index

moves from zero through 10°, 20°, 30°, &c.; the latter when it moves backwards from zero through 90°, 80°, 70°, &c.

In order to obtain some knowledge of how this apparatus would act, I proceeded as follows:—A hygrometer, made according to the foregoing description, was placed under the glass receiver, on its plate, resting on several discs of spongio-piline impregnated with chloride of calcium and well dried. The arrangement was thus left for two days. The index had ceased to move, and indicated what is considered the point of extreme dryness. The hygrometer was then entirely immersed in water: the index immediately began to turn, and continued to do so quickly, until it had moved round the dial ten times, and a few degrees over; the whole time occupied being 62 minutes. This was of course the point of extreme moisture. When taken out of the water and exposed to the air, it returned in 69 minutes, but stopped at the ninth round, the weather having become cloudy.

The method of total immersion was used by De Luc in graduating his whalebone hygrometer, and by Leslie for the graduation of his ivory instrument. This method has been objected to as not representing what really takes place in the atmosphere, which is the precipitation of water in the state of ultimate division, or as a vapour at the point of deposition. I do not perceive any practical difference between the two modes of expression: what is deposited is water in ultimate particles, and if these coalesce, rain or running water results, which is what I use for rapidly producing extreme moisture. When a gut line has been exposed for a long time to saturated vapour, it is found covered with adhering globules of water; total immersion could do no more; the gut line will, in either case, absorb only to saturation.

Whether there be, in the higher atmosphere, a region of *absolute* dryness is of no use to inquire; but that there is a region of *extreme* dryness, we have the evidence of those who ascended in balloons, who reported that their hygrometers indicated an increasing siccity in proportion as they ascended, and to such a degree that paper became corrugated as if by fire, and thirst became intolerable. With such siccity we have nothing to do. In our experiments, we attain what we call *extreme* dryness by the employment of exsiccants; but dryness so produced is probably not absolute. I adopt therefore the two fixed points, extreme dryness and extreme moisture, both artificially produced, as the limits of my scale; and as the representatives of the conditions which alternately exist in the heavens; and I assume the hygrometric range between them to be measured by the twisting and untwisting of the gut line, as shown by its index and graduated circle.

A hygrometer, of whatever construction, can only indicate the atmospheric moisture of its own immediate neighbourhood, which may be called its local atmosphere, and which is continually changing, either by the addition or subtraction of water in the state of vapour; or by change of temperature or of pressure.

Berzelius distinguished water into the three states of aqueous gas, aqueous vapour, and liquid water. When aqueous gas is cooled in the air, vapour is formed, which is water in its ultimate division; but if cooled on the surface of a cold solid, it does not form vapour, but passes at once into liquid water. In the case of this hygrometer, aqueous gas is cooled on the gut line and becomes water. When the index stands at 0 (represented by a point) the gut line, having been exposed to the action of exsiccants, is supposed to be anhydrous.

When the gut line begins to absorb, it begins to turn the index; and when this has travelled ten times round, it has completed the hygrometric range of the local atmosphere, and of the instrument.

The length of gut line actually in operation, exclusive of the silk, which gave 10 rounds of the index in my trials, was 3¼ inches; but the stem which holds it is adjustable to a greater or less length as may be necessary to produce 10 rounds.

With regard to the working of this instrument, the following will give some idea, being the result of a trial of a new gut line in what may be called its natural state without any exsiccation. The hygrometer was covered with a glass cylinder, half of which was lined with wet blotting paper. If the gut-line had been previously exsiccated, it would have given eleven turns to the index, and a few degrees.

1st	round	performed in	7¼	minutes.
2nd	,,	,,	7½	,,
3rd	,,	,,	8½	,,
4th	,,	,,	8¾	,,
5th	,,	,,	9	,,
6th	,,	,,	11	,,
7th	,,	,,	13	,,
8th	,,	,,	18	,,
9th	,,	,,	27	,,
10th	,,	,,	61	,,

A similar hygrometer, being totally immersed in water, the index went round eight times in five minutes, in times not very unequal.

When the hygrometer is exposed to the natural dampness of the air, the first two or three, or perhaps four, or five revolutions of the index are scarcely different, in point of time, unless the atmosphere have meanwhile changed hygrometrically, which it so frequently does. Much will depend on the thinness of the gut line. Proper lengths from the same string may be preserved indefinitely in a glass tube of very small bore sealed with wax. A gut line, long in use, is easily removed and replaced, and may not require to be changed but after a long service; especially if the glass receiver be constantly kept on when the hygrometer is not in use.

This hygrometer, when suddenly brought into the open air, after confinement in the house, although the index may immediately begin to move, does not at once truly show the state of the atmosphere,

as do those of Hooke, Regnault, and others, nor until the index have passed rapidly though the degrees of moisture which existed in the open air previously to its exposure. The index then pauses, or passes slowly for a while, and shows the real existing state. The absorption of water into the pores of a hard elastic substance cannot be instantaneous.

The hygrometric range of the instrument may be assumed to consist of any number of degrees at pleasure, provided that the number be comprised within the turns which the gut line is capable of giving to the index. The gut line selected as the proper medium for this hygrometer, when subjected alternately to the two extremes, in my trials gave to the index ten rounds of a circle divided into 100 degrees. Neglecting a few redundant degrees, there are in its whole range 1000 degrees between the two extremes. This number is therefore the denominator of a fraction of which the numerator is any number of degrees indicated by the revolutions and parts of a revolution of the index on any occasion. Thus, the gut line having been previously well dried by exsiccants, suppose the index to have moved twice round the dial, and then stopped, the fraction of saturation would be $\frac{200}{1000}$ or 0·2. Or if, after an absence, I find two spherules in the receiver, the index perhaps pointing to 40° besides, then the fraction of saturation would be 0·24. If the index go round ten times, the atmosphere is saturated or 1·0; but this is a rare occurrence, and never happened in my trials with this instrument unless by contrivance. So far of notation: now as to the value of the degrees.

A degree on this hygrometer represents the presence in its local atmosphere of the one thousandth part of the moisture which would be necessary to produce saturation. When the hygrometer, having been previously well dried, marks 100° (or better decimally 0·1) that is one round of the index on the dial, I know that the atmosphere contains one-tenth part of the water that would saturate it. When the hygrometer marks 0·5, the observer learns that he is in an atmosphere midway between the extremes of moisture and dryness. If the degree indicated be 0·84 it means that the index has gone round the graduated circle eight times and 40 degrees besides, in all 0·84. Were the hygrometer to mark any degree much below 0·1, it would announce an intolerably dry atmosphere, which, if permanent, would prove to human beings dangerously unwholesome or destructive to life.

It need scarcely be observed that the foregoing degrees of dampness are convertible into degrees of dryness by subtracting them from unity, and taking the difference.

As the agreement of two hygrometers, placed under the same circumstances, leads to a presumption of the correctness of both, and as comparability is desirable for many purposes of research, I made several experiments with a view of ascertaining if the hygrometer here described possessed that important quality.

Two hygrometer frames of similar construction and size were procured. A gut string, the thinnest, most even, and most equally twisted was selected; and, from the *middle* of it, a piece twelve inches long was cut and divided into two equal parts, which weighed 0·54 of a grain each. A string was made of a few fibres of floss silk, very loosely twisted together, divided into two, and a sufficient knot made on the end of each. The gut and silk lines were connected by the brass cones to form two compound-lines as already described, and one of these with its index was fixed in each hygrometer frame, care being taken that the same length of gut was exposed to the action of the air, which was easily effected by the sliding stem. The compound lines, hanging loosely, resumed their natural twist, and in this state were left for several hours. Each was then gradually tightened until the rapidity of the vibrations of the index of each, when moved equally from its position of rest and suddenly let loose, was equal in both; and of this the eye seems to be a sufficient judge. The more rapid the vibration the greater the tension. The weakest tension that will give vibrations, and carry the index in both cases equally, is the proper condition of the two hygrometers for comparison. It should be stated that one of these instruments had a silk string twice as long as the other.

I shall now state the results of a comparison of those two hygrometers, placed closely beside each other in the open air, and under shelter, during eight days. In this period, I inspected them 119 times, at unequal intervals, while the indexes traversed the dials ten times round—backwards sometimes, forwards other times—but in effect ten times. In the following statement, no case is recorded wherein the indexes remained at the same degree as at the preceding inspection:—

In 15 inspections the hygrometers agreed precisely.
In 18 inspections they differed one degree.
In 14 inspections they differed two degrees.
In 4 inspections they differed three degrees.

During these 51 inspections, the indexes had gone round the dials six times. But during the remaining four rounds the differences were much greater, reaching 20 degrees, and once 25 degrees. This might have been foreseen; for as each new round of each index gave its silk string an additional twist, and as one of the silk strings, being but half the length, offered double resistance to its gut line, the latter was at length nearly overpowered, and moved its index more feebly and slowly, while the unobstructed one moved nearly at its original rate: hence the increasing difference between. There may have been many other cases of agreement not here recorded; and but for this impediment it is fair to presume that there would have been agreement throughout the whole scale. The movements were very numerous, the weather being stormy and changeable.

At a subsequent period, I made 77 inspections, with the following results, during a week, at unequal intervals, the silk strings being equal:—

In 31 inspections the hygrometers agreed precisely.
In 13 they differed one degree.
In 18 they differed two degrees.
In 5 they differed four degrees.
In 6 they differed five degrees.
In 3 they differed six degrees.
In 1 they differed ten degrees.

The instances in which the two hygrometers agreed, or nearly agreed, are sufficiently numerous to induce a belief that those in which they disagreed were occasioned by the same causes as Regnault found to affect his psychrometer momentarily, which he says "must be attributed to the successive arrivals of air which contain quantities of moisture often very different." Whether this be so or not, a difference of three or four degrees in a thousand of the range must be of small effect in any inquiry, and is not a greater imperfection than has been found in other hygrometers of acknowledged efficiency. Thus, it is stated that two of De Luc's whalebone hygrometers, being compared, were found to differ five degrees, although the scale of each had been recently adjusted; and that the best hair hygrometers of Saussure, when compared, often deviated several degrees in the same medium. (Edinb. Encyclop., Art. Hygrom., p. 392).

From the facts stated, I think it may be admitted that this hygrometer is a comparable instrument, when carefully made and managed. There is one other office which a hygrometer has to perform. It is not sufficient that it shall inform us of the presence of water in the atmosphere; we require to know how much—the ponderable quantity in grains' weight which a vacuum of a definite measure, such as a cubic foot, may at any time contain, without the knowledge of which the words "dampness," and "dryness," give no precise information.

The hygrometer here described represents the natural unsaturated state of the atmosphere: ten rounds or 1000 degrees constitute its scale; all less numbers of degrees constitute its fraction of saturation. This fraction is the measurer of the moisture belonging to all existing temperatures of the time as they present themselves; but it does not give information as to the actual ponderable quantity of water present in a certain volume of air or space, such as a cubic foot, may at any time contain.

To arrive at the knowledge of this quantity, we must, in the first instance, seek the aid of experiment and computation. The first step will be to find the dew-point: the easiest method for which is the cold water process of Le Roy, recommended by Dalton, Berzelius, and others. Suppose the dew-point to be 60°, find the elasticity of that temperature from the tables of Regnault, interpreted and adapted to

the latitude of Dublin by the Rev. Dr. Dixon. Divide that elasticity into the height of the barometer. Divide the quotient into the weight of a cubic foot of aqueous vapour, at the temperature of the dew-point: the quotient will be the grains' weight of water contained in a cubic foot of the atmosphere, at that time.

Thus, at the dew-point 60°, the elasticity of vapour is 0·5178, and this elasticity divided into the barometric height 30 gives 58, and dividing this 58 into 372, the weight in grains of a cubic foot of saturated vapour at 60°, gives 6·4 grains as the weight of water contained in a cubic foot of the atmosphere or space, at that time, under the circumstances stated.

This computation shows what weight of aqueous vapour would be found in a cubic foot of air or space if the vapour were saturated, but it is almost never saturated, as is well known to those who have long observed the psychrometer, the two bulbs of which almost never agree. In De Luc's experience, he found them to agree but once. During my own observation of an excellent psychrometer, I never found the two bulbs to agree exactly, the difference varying from half a degree to 10 or 12 thermometric degrees, after six or eight hours of incessant rain; and other observers have found the difference much greater. This hygrometer shows how far the air is from saturation, that point being the completion of the tenth round of the index: the fraction of saturation shows how much has been already accomplished of the computed quantity of water, and by the distance of the index from the completion of the tenth round, how much is yet to be accomplished.

The computation shows how much saturated vapour of water the cubic foot would contain; the hygrometer shows how much it does contain, and also the deficiency—i. e. the quantity which, if added to that actually contained, would make up the computed quantity. If the index went ten times round the dial, the atmosphere would be saturated and could hold no more, that being the extreme of moisture. But as the air is, we may say, never saturated, the index will not turn round ten times, unless placed in an artificial atmosphere of aqueous vapour. On examining the state of the hygrometer at any time, we find perhaps that two spherules have been thrown off, and that the index points to several degrees more. Suppose both together indicate 250°, we learn that the atmosphere is one quarter saturated, and as computation has shown that 6·4 grains of water would be saturation at 60°, and as one quarter only of the saturating quantity is present, we learn that 1⅗ grains of water are suspended in vapour at that time, in every cubic foot of air or space.

In fine, whatever may be the fraction of saturation presented by the hygrometer, that will be the fraction necessary to make up the weight of water which computation has shown to belong to that temperature when saturated.

A few suggestions relative to the care of the instrument may be useful. The compound line should not be kept tight when not in use;

and never more tight than is necessary to keep it in its rectilinear position: if the index, when moved, vibrate much and very rapidly the compound line is too tight.

Old gut-lines act sufficiently well for hygroscopic purposes; but for exact experiments a new gut line should be used; it is easily fixed in, and the cost of a number of them is almost nominal. The silk line need scarcely ever be renewed.

When exact results are required, the natural zero should be the starting point; in other cases, any degree may be used for that purpose.

It is proper to mention, although it might have been anticipated, that this hygrometer scarcely acts in very frosty weather. When aqueous vapour is converted into icy particles, it is not in condition to be either absorbed or liberated: hence the gut line, although having an affinity for water, has none for ice. In continued hard frosts, the gut line is even permanently injured by tension and rendered unfit for service, so much so, as to be no longer affected by damp or drought, although originally moveable by the breath or the proximity of warm hands.

The hygrometer being, as its name indicates, the measure of moisture, that degree at which its scale commences is therefore the natural zero; but throughout the foregoing description, the word zero is for shortness used to signify the completion of any round of the circle, that is any arrival of the index at the hundrdeth degree of the graduated circle, which may occur ten times while its thousand degrees are being completed. The natural zero can be practically attained only by exposure of the gut line to the influence of exsiccants until the index stand motionless, which may not take place for several hours.

It would be a depreciation of the value of this little instrument were it viewed as a philosophical trifle. It may be made conducive to health and comfort, and useful for a variety of purposes. In warm climates the atmosphere at times becomes so dry and parching that it is found necessary to ameliorate its effects by placing vessels of water in the most airy parts of the house, and in bed-rooms, and even on warm stoves in order to promote evaporation. The opposite condition of redundant moisture in the air is not without inconvenience—"We have (says Ganot) the feeling of oppression, even at moderate temperatures, when we are in an atmosphere saturated by moisture in which no evaporation takes place." In either of these states of the air the hygrometer points to the evil and to the remedy.

The instrument is available for ascertaining the dampness of new buildings or apartments, or the suitableness of the external air for valetudinarians. It may prove useful to the chemist, its small size rendering it adaptable to his purposes. The air of cellars may be tested as to its fitness for the storage of provisions, wines, &c. It is perhaps the only manageable hygrometer for aeronauts, no preparation at the time of observation being necessary. It is convenient for comparing the air of mountains and valleys or widely separated localities, each of two obser-

vers being provided with a gut line from the same string. It shows how distant or how near is the point of liquefaction of vapour in the air, and thence the probability of a fall of rain, information so important to the gardener or agriculturist.

When a register is to be kept, during absence of a few hours in wet weather, or of many hours or even days in dry weather, the gut line must be previously brought to the maximum of dryness by means of the exsiccation discs, and the index brought to zero. A spherule is to be placed on each side of the index. On the return of the observer, if he find both spherules in the receiver, he is not necessarily to infer that damp continuously accumulated in the air to that amount, without intermission: there may have been advances and retrocessions of the index, the former having been, on that occasion, greater than the latter, until the spherules had been finally pushed through the perforation. The spherules and index together give the maximum, up to the moment of observation.

A method of bringing the index to zero has been already given, but it is uncertain and only approximate. In order to bring the index precisely to zero after being thus approximated, the tightening pin will be found to have complete control, but should not be used to great extent, as it affects the sensibility of the gut line.

To learn the state of the atmosphere, at any time, the indication of the index will be generally insufficient: it may have previously traversed the circle several times by alternate absorption and extrication of moisture by the gut line, and of this the index gives no account. The amount in degrees, indicated by the spherules found in the receiver, if any, must be added to the degrees shown by the index. The sum is the present hygrometric state of the atmosphere.

As the proper *situs* of a hygrometer is the open air, it must be protected from vicissitudes of weather. It may be inclosed in a pocket lantern, consisting of three sides of glass closely glazed in a japanned tin frame, the fourth side being a door with many air-holes at the bottom. The top of the lantern may be constructed, in the usual way, with two arches of tin plate crossing each other at right angles. Handsome pocket lanterns of this kind are commonly sold, but the open arches at top should be covered with muslin.

The lantern, containing the hygrometer will, during rain and high wind, require to be included in a cubical tin case, so much larger than the lantern as will allow the entrance of a sufficient current of air through one side, which is to be left open. The case should be loaded, at bottom, with lead.

The hygrometer should stand in a circular shallow tin tray, the bottom of which is covered inside with a disc of cloth to prevent the rebounding of the elastic spherules when they fall. This is the receiver previously mentioned. It shows at a glance how many spherules have fallen.

During the late rainy weather I made a number of trials of my

hygrometer. I shall describe one of them, as it will give a clear idea of some of the preceding statements.

The hygrometer having been exposed to the exsiccating discs in the drying apparatus for two days, the index stood at 2°—we may say at zero. Being placed in its lantern, the index began to move; it was raining at the time. In two hours the index had moved round twice, and had deposited two spherules: it then began to move more and more slowly, stopping occasionally and moving forward again, and sometimes retrograding, but still it progressed until it reached 49°, where it rested for upwards of three hours. Calling the starting point zero and the resting point 50°, the hygrometric state of the atmosphere, including the two rounds, was 250° or 0·25. The rain had ceased: the index began to retrograde, and advanced and receded alternately, but next morning it was found exactly at zero. Thus having advanced 250° and retrograded 150°, the gut line must have retained the aqueous representative of 100°.

To prove the correctness of this inference, it should happen that, by subjecting the hygrometer to the exsiccating discs, the index should retrograde 50°. On making the trial, I was pleased to find that this happened exactly as it ought: for, after exposure of the hygrometer to the exsiccating discs during a night, the index, next morning, stood exactly at zero, and further exposure, during several hours, did not make any change.

If, without this second exposure to the exsiccating discs, I had at some subsequent period placed the hygrometer on duty, and found the index to point, suppose to 80°, it is obvious what a mistake it would be to conclude that this degree indicated the atmospheric state, the real indication being 180°. This source of error must be always attended to, when the hygrometric state of the atmosphere is to be ascertained.

XL.—NOTES ON APPLIED MECHANICS, III., IV. BY ROBERT STAWELL BALL, LL. D..

(*Continued from Proceedings*, vol. i., ser. 2, page 245.)

[Read April 14, 1873.]

III.—OF THE THEORY OF LONG PILLARS.

IN the "Educational Times," November, 1872, I proved the following approximate formula (previously proposed in question 3809) connecting the load on the pillar with the deflection of the centre for the case where the curve has no point of inflection—

$$W = \frac{\pi^2 EI}{L^2}\left(1 + \frac{\pi^2 D^2}{8L^2}\right).$$

W being the load on the pillar.

L the length.

E the coefficient of elasticity.
I the moment of inertia.
D the deflection of the centre.

After the publication of Q. 3809, the Rev. R. Townsend, F.T.C.D., called my attention to the fact, that there was a discrepancy between my result and a similar formula arrived at by Poisson, Mécanique, 2nd Edition, vol. II., p. 612. Poisson's formula, translated into the present notation, gives

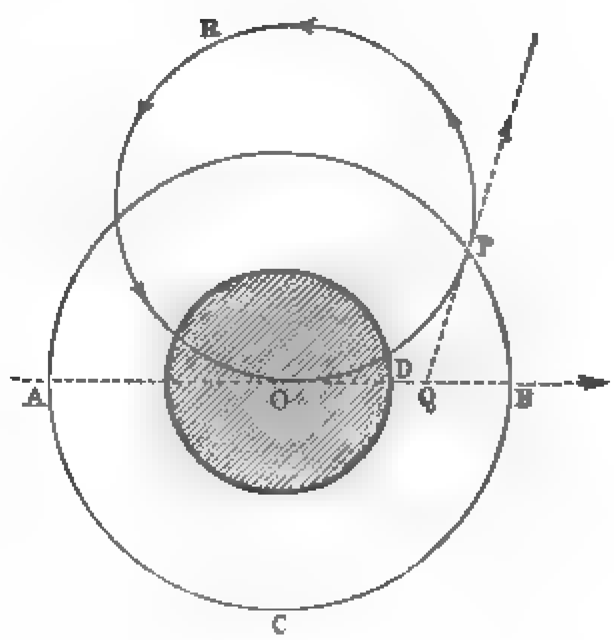
$$W = \frac{\pi^2 EI}{L^2}\left(1 + \frac{\pi^2 D^2}{4L^2}\right).$$

The discrepancy has arisen from the circumstance that Poisson has considered $\frac{dy^2}{dx^2}$ as negligible in deducing the differential equation of the curve, while in finding the length of the curve, he retains a term of the same order. If terms of the magnitude $\frac{dy^2}{dx^2}$ be retained ***throughout*** the investigation, as manifestly is necessary for a legitimate approximation, then the 4 in the denominator of the second term in Poisson's result should be replaced by an 8.

The peculiarity of this expression has been already adverted to, namely, that it does not vanish when D vanishes.

IV.—Note on a Hydrodynamical Theorem due to Professor Stokes.

A circular cylinder moves through an indefinitely extended incompressible liquid: determine the movements of the particles of the liquid.



The present note is merely to present in a geometrical form the solution of this problem given by Professor Stokes.

Let the shaded portion of the figure represent the cylinder of which O is the centre.

Let AOB be the direction in which the cylinder is moving.

To find the direction in which a particle of the liquid P is moving, describe a circle POR touching AB at O, then P is moving in the direction of the tangent to the circle, and all points on the circle are moving in the directions of the arrows. Further, the velocity of P varies inversely as the square of the distance OP, so that the circle APC is the locus of points moving with the same velocity: the velocity of

every point is therefore fully determined, since the particle at D moves with the velocity of the cylinder. The Kinetic energy in the liquid is equal to that possessed by a cylinder of the liquid of the same size and moving with the same velocity as the cylinder which has produced the movement.

XLI.—DESCRIPTION OF AN INSTRUMENT FOR KEEPING UP ARTIFICIAL RESPIRATION. By DR. NICHOLAS FURLONG. (With Plates XXVI. and XXVII., Science.)

[Read April 28, 1873.]

THE instrument I have used for keeping up artificial respiration was constructed by myself, and is a modification of one originally devised by my father, Dr. A. Furlong, of Streamville, Co. Wexford.

Many years since it occurred to him when endeavouring to resuscitate some persons asphyxiated by drowning, that an instrument similar to what I have sketched in section, at fig. 3., ought to prove useful.

He never had one constructed of sufficient size to test its practical utility, but his model, which I have frequently examined, had the form of an ordinary pair of bellows, but with two compartments, each of which had a separate pipe or tube.

It will easily be seen that when these pipes were fixed air-tight in either nostril, and the mouth and lips kept perfectly closed, that on divaricating the handles *a á*, the chamber A filled through the pipe P with water or air from the lungs, while the chamber B filled through the lower valve with fresh air. On again approximating the handles, the chamber A emptied itself through the upper valve, the chamber B at the same time transmitting its charge of fresh air to the lungs.

Though the action of my instrument is essentially the same as my father's, yet it differs from it in some other respects.—*First*, in form, which is a matter of very little consequence. *Secondly*, in having *but one pipe* inserted into a *third* or central chamber C, communicating with the other two by means of apertures presided over by suitable valves. The importance of this for my purpose is obvious, the trachea being by far the most convenient part through which to carry on artificial respiration. *Thirdly*, in being self-acting in one direction through the agency of elastic bands, which enabled me to dispense with the services of an assistant, and keep it in full action by a treadle movement. *Fourthly*, in the idea of a regulating spring (Figures 4 and 5, Pl. XXVII., Science) over the valve V (see Fig. 1, Pl. XXVI., Science), to obviate the tendency of the air to pass directly from chamber A to chamber B.

The regulator, fig. 4, would only be necessary in the case of large animals, where the resistance offered by the lungs was very great; it

may be entirely dispensed with in small animals, such as rabbits, hedgehogs, &c., &c., with which I have found the instrument exhibited to work most efficiently.

The upper part of the apparatus is fixed underneath the operating table by three strong cords, as seen in fig. 2, the inferior part is likewise fixed by cords to one end of a piece of wood about 16 inches long by 4 broad and $\frac{3}{4}$ thick. The other end of this board is hinged to the floor, and thus acts as a treadle. Of course when the bellows is closed, the end of the treadle to which it is attached should be raised from the floor sufficiently to allow the complete expansion of the bellows when the treadle is depressed.

XLII.—The Anatomy of Chæropsis Liberiensis. By Alexander Macalister, M. B., M. R. I. A., Professor of Comparative Anatomy in the University of Dublin. (With Plate XXVIII., Science.)

[Read June 9, 1873.]

In 1844, Mr. S. G. Morton published in the Proceedings of the Academy of Natural Sciences of Philadelphia (vol. ii., p. 14), an account of the bones of a small species of hippopotamus brought by Dr. Goheen, of Monrovia, which he named H. minor. These bones (two skulls) had been procured on the banks of the St. Paul River, Liberia. The name Hippopotamus minor being preoccupied by one of Cuvier's fossil species, Mr. Morton later (Journal of the same Academy, second series, vol. i., 1849), substituted H. Liberiensis, for the new small form. A second and more detailed description at the hands of Professor Leidy led to the founding by that comparative anatomist of a new genus for its reception, which he at first called Chærodes (preoccupied in another department) and finally Chæropsis. This creature has more recently (1867), received another name from the late Professor Gratiolet, Ditomeodon, which, however, being subsequent to Chæropsis, must be abandoned. M. Alphonse Milne Edwards having obtained from Prince Napoleon a skin, a skeleton, and two skulls of this species, has written thereon a monograph (Recherches pour servir a l'Histoire Naturelle des Mammifères, Livraison 2, 1868).

The present specimen was found by a native hunter in Liberia, by whom its mother was shot. It was supposed to be one or two weeks old. On its being brought alive to Governor Pope Hennessy, he kindly directed that it should be transmitted to the Dublin Zoological Gardens, in the care of Dr. Price. Unfortunately on its arrival in Liverpool the animal caught cold, which caused violent inflammation of both lungs, and in spite of the care taken of it she did not survive her arrival in the gardens by five minutes. By this time she was supposed to be eight weeks old, and her dimensions are as follow:—

	Inches.		Inches.
Length,	22·5	Width between eyes,	3·0
Height at shoulder,	11·5	Length from eyes to ear,	2·0
„ „ hip,	12·0	Length of fore leg,	4·0
Girth at back of shoulder,	22·5	Length of hind leg,	4·5
„ „ front of thigh,	23·5	Length of rictus of mouth,	5·0
Length of head from snout to front of the ear,	4·60	Breadth across angle of mandible	4·25

The skin is dark brown with a light reddish tint, hairs are only present at the base and within the cavity of the concha auris, as well as on the muzzle, where they are stiff, and a few scattered softer hairs exist on the body.

The head is small, the face shorter than in the common hippopotamus. In the adult the eyes are midway between the occiput and the snout. The toes are united by a membrane.

The other points of importance in its osteology are so carefully detailed in Milne Edwards' paper that I need not recapitulate them here. My specimen showed the same arrangements as far as they could be noticed in a young specimen. The vertebræ were seven cervical, fourteen dorsal, five lumbar, four sacral, at least ten caudal, six sternebers in the sternum, and a wide xiphoid cartilage. There was no ligamentum teres in the hip joint.

In the splanchnology of this young specimen there were some very interesting features; the heart was wide, short, and with a closed foramen ovale, a small Eustachian and rudimental Thebesian valve. The right superior vena cava is large; a very fine vein, joining the left innominate at its origin to the coronary, was the only trace of a left superior vena cava; the right vena azygos was large, the left small, both arch over the bronchi and end in the two superior cavæ; there were no valves in the left or right renal veins. The aorta gave off from its arch an innominate artery, which soon bifurcated; one branch being the left carotid, the other being the common stem for the right carotid and right subclavian. The left vertebral and left carotid arose separately from the aortic arch. The superior mesenteric and cœliac axis came off as a common trunk, and there was an inferior mesenteric; the internal and external iliacs arose at one point by a very short common trunk on each side. I could find no caudal glomeruli or other trace of the coccygeal gland. There was a single axillary artery; no retia in the upper limb, nor in the neck. The common carotid bifurcated at the lower edge of the larynx. The inferior vena cava was thick-walled above the liver; having pierced the diaphragm, it was directed forwards for a short distance, about an inch and a-half, then ascended, pierced the pericardium which, as in the walrus, was not attached to the trilobate single cordiform tendon of the diaphragm, and finally ended in the right auricle. There was a very high bifurcation of the right bronchus, forming very nearly a median tube. The stomachs were four, and as usual; the intestine was thirty-two feet long, and was not provided with a cœcum. The choledic duct opens

six inches below the pylorus. The kidneys were slightly lobulated. The liver was solid quadrilateral, with an elongated triangular gall bladder, an obliterated umbilical vein, but no ductus venosus, and a vena cava imbedded in its posterior border.

The hypoglossal, vagus and cervical sympathetic were closely connected; the first named separated and passed inwards, the two others pass downwards, united as a single cord as far as the seventh cervical vertebra. Here they separate; the two vagi pass inwards behind the roots of the lungs to the œsophagus, where they lie, the left behind and the right in front, then they soon coalesce into a single cord, which extends as far downwards as the stomach, and there it terminates. The sympathetic cord forms immediately on its separation a large ganglion, succeeded by a chain of others as far as the diaphragm. The two trunk sympathetic cords unite around the cœliac axis and form the large solar plexus, each semilunar ganglion taking the place of a last dorsal ganglion. From this the usual sets of branches stream off, and the trunk nerve on each side passes along the lumbar and sacral vertebræ, forming lumbar and sacral ganglia, the last sacral being a ganglion impar, and the inner branches form a large hypogastric plexus. The pleuræ as they pass from the pericardium to the diaphragm are strengthened by fibrous tissue from the pericardium, and have branching on them the phrenic nerves.

The brain was well developed and well convoluted. The callosal gyrus was long and rounded behind, the internal perpendicular sulcus and central convolution were large, and a rudimental calcarine groove existed on the postero-inferior surface of the hemisphere. The upper surface showed many shallow involutions and well marked inner frontal. The *Vorzwickel*, 1st and 3rd *plis de passage externe* (Gratiolet), *Zwickel* and a small occipital *Zungenförmiges Läppchen* (Huschke) exist. The figures (Plate XXVIII., Figs. 1, 3) will show this lobulation better than any description.

The myology of the specimen will be seen to present a general resemblance to that of the common hippopotamus, and a more distant likeness to that of the pig.

The trapezius was a single inseparable muscle, passing from the inner fourth of the occiput, the middle line of the neck, and the anterior part of the back, to be inserted into the scapular spine; its lowest fibres form a strong tendon into the tubercle of Retzius on the scapular spine, a separate cleido-occipital (= clavicular trapezius) arose from the par-occipital and post tympanic process external to the last, and is inserted into the clavicular deltoid (with which it is continuous), having no trace of an inscription at the point of junction; the final destination of the deltoidal part of this muscle, after flowing over the inside of the shoulder is into the lower end of the humerus, external to the biceps and brachialis anticus.

The sterno-mastoid arose from the presternum, and was inserted along with and in front of the last. The trachelo-acromial, though very separate at its atlantic origin, is blended with the acromial part

of the trapezius. There is no cleidomastoid nor omohyoid. Of these protractors, the sterno-mastoid = 1; trapezius = 2·20; trachelo-acromial = 1·10; and the cleido-occipital + clavicular deltoid = 2·50.

The rhomboideus occipitalis and major were large, the minor small, but they were not definitely separable, and the whole exceeded the sterno-mastoid in weight by $\frac{1}{5}$th. The latissimus dorsi arose from the three lowest ribs, from the spines of the hindmost eight dorsal vertebræ, and by the lumbar fascia from the lumbar spines; it was inserted along with and partly connected to the teres major (which was normal, and was only $\frac{1}{7}$ of the latissimus). These two muscles in weight exactly equalled the combined cleido-occipital, clavicular deltoid and the trachelo-acromial.

The pectoralis major consisted of: 1st, a quadrate presternal part, whose fibres passed from one side to the other into the fascia of the arm for the whole length; 2ndly, of the usual sterno-costal part, which extended to two inches of the linea alba, was large and inserted as usual, higher up into the head of the humerus; this muscle equalled in bulk all the neuro-scapular muscles together. There was no proper pectoralis minor. The serratus magnus arose from ten ribs, and its levator anguli scapulæ extension, which was as usual inseparable, arose from six cervical transverse processes. This muscle equalled the pectoral in weight. A strong sterno-scapularis stretched from the presternum to the fascia above the supra-spinatus, by which it was continued into the meso-scapula; this muscle equalled the trachelo-acromial in size.

The deltoideus arose as a continuous muscle from the spine of the scapula and from the infra-spinous fascia, and was inserted into the deltoidal crest; this muscle was small, only half the size of the sterno-scapularis. The supra-spinatus was to the infra-spinatus as 14 : 9, and the tendons of both lay outside the capsule of the joint. The supra-spinatus was more than double the deltoid in weight, and the sub-scapularis was very little larger than the last-named. A sub-scapularis secundus could easily be separated.

The coraco-brachialis was represented by the long form, which was crossed, not pierced by the musculo-cutaneous nerve; this muscle was small but extended nearly to the inner condyle. The teres minor was distinct as usual, half the size of the coraco-brachial and $\frac{1}{18}$ that of the infraspinatus.

The biceps arose by a long tendon from the summit of the glenoid cavity; this tendon was very thick, and ended in a penniform belly, which was inserted by two tendons, one into the anterior and inner side of the head of the radius, and the other winding round the head of the radius ran into the inner lip of the lesser sigmoid cavity of the ulna, becoming confluent with the orbicular ligament, a slip extends from the latter insertion into the fascia of the forearm. The biceps withal is a small muscle, being only equal to $\frac{1}{4}$ of the supra-spinatus. The brachialis anticus is very spiral in its course, and is inserted into the inner side of the *radius* below its head, anterior to the first tendon of the

biceps; it is double the biceps in weight. The triceps is enormous, its long head arises from the whole edge of the post-scapula, and the humeral head was indivisible and closely joined to the scapular. This muscle is four times the weight of the combined biceps and brachialis. There is no dorsi epitrochlearis, and the external anconeus (which exists) is inseparable from the triceps.

In the forearm there is no pronator teres, nor supinator longus. The flexor carpi radialis extends from the inner condyle to the base of the first metatarsal (that of the index). The palmaris longus is half the size of the foregoing, and is nearly inseparable from the flexor carpi ulnaris. That muscle has two heads which are quite separate, an olecranal and a condyloid, each of which equals the flexor carpi radialis; they were inserted by a common tendon into the pisiform bone, and the palmaris longus external thereto ended in the flat fascia of the palm.

The flexor sublimis was very small, equalling the flexor carpi radialis, and sent perforated tendons to the 1st, 2nd, and 3rd digits. The flexor pollicis and digitorum both arose from the humerus and slightly from the forearm bones; the former was $\frac{1}{3}$rd of the latter, and both combined were five times larger than the flexor carpi radialis and $\frac{1}{3}$rd the size of the brachialis anticus. The pronator quadratus was very small, barely detectible, and did not occupy $\frac{1}{7}$th of the length of the interosseous space.

There was a single extensor carpi radialis which was inserted by one tendon into the second metacarpal bone; this muscle was the largest on the forearm, equalling all the digit flexors combined; there was no supinator brevis. The extensor digitorum longus sent off three tendons to the 2nd, 3rd, and 4th digits; this muscle was also large, being more than $\frac{2}{3}$rds the foregoing. The extensor minimi digiti sent off two tendons to the first and second phalanges of the 3rd and 4th digits; it was exactly half the size of the common extensor.

The extensor carpi ulnaris arose by a tendon from the external condyle, it wound round to the flexor side of the forearm, and was inserted into the pisiform: it equalled the flexor carpi radialis in size. Extensor ossis metacarpi pollicis was about the same size, and arose mainly from the radius as well as from the interosseous space; it is inserted into a sesamoid bone at the base of the 1st digit. There was one lumbricalis to the radial side of the 4th digit; an abductór minimi digiti from the pisiform to the 1st phalanx, a flexor brevis for the same finger from the head of the 4th metacarpal and an adductor from the os magnum. The dorsal interossei are, abductor indicis from the scaphoid and 1st metacarpal to the 1st phalanx, abductor (radialis) medii, ulnaris medii, and abductor annularis, which is the only bicipital one in the series. The palmar interossei are adductor annularis and a long (carpal) and a short (metacarpal) adductor indicis inserted separately. (Plate XXVIII., Fig. 5.)

The splenius arose from the cervical and upper dorsal spines, and was inserted into the occiput and into the atlas; it had one tendinous inscription. The serratus posticus extended from the 6th to the 15th rib, the trachelo-mastoid was large, and arose from the last cervical and from the first dorsal transverse process, and was inserted into the para-mastoid process. The complexus arose from the 2nd to the 7th cervical vertebræ as well as from the upper dorsals; the deeper spinal muscles were as usual, the scalenus anticus extended from the 1st rib to the 2-7 cervical vertebræ, the S. medius from the 5-7 cervical and the S. posticus from the 7th cervical, both to the 1st rib. The rectus capitis anticus major stretched from the 2-6 cervical vertebræ to the basilar process.

The gluteus maximus, biceps and agitator caudæ were inseparable, and arose from the fascia over the ilium and the post sacral vertebræ; the insertion was continuous along the outside of the thigh as far as the knee, and thence into the head of the fibula and fascia over that bone; this muscle equalled the great pectoral in weight. The gluteus medius was thick, extended even above the iliac crest from the lumbar fascia, and was inserted as usual; it was $\frac{3}{5}$th the size of the last. There is no pyriformis. The gluteus minimus is wide, $\frac{1}{6}$th of the last, and the marginal part represents gluteus quartus; internal to it lies the gluteus quintus, which arises fleshy under the origin of the rectus femoris and is inserted into the outside of the femur below the great trochanter; this muscle is exceedingly small. The tensor vaginæ femoris arises as usual, and is inserted into the knee by a strong band and into the outside of the thigh; it is nearly half the size of gluteus medius. The quadratus femoris I could not separate from the adductor magnus, nor could the condyloid part of this muscle be separated without tearing from the semimembranosus; they together made a muscular series equal to the gluteus medius. The obturator externus was distinct, the internus and its small gemelli was $\frac{1}{3}$rd its size.

The sartorius was twofold, one part arose from the inner surface of the ramus of the pubis; the fibres passed over the brim of the pelvis and were inserted as usual; the outer part arose from the sheath of the iliacus tendon, and lay parallel and external to the first part; it is attached partly to the patella and partly to the inner condyle of the tibia: both together are half the weight of the gluteus minimus, and the outer is to the inner as 1 to 4.

The psoas magnus arises from the ilium, and from the transverse processes of the lumbar vertebræ; it is a large muscle, nearly as large as the biceps and gluteus maximus; the psoas parvus is small, only being the 40th part of the magnus.

The pectineus is very minute, has a very small insertion into the femur anterior to and above the lesser trochanter. The adductor longus is larger, being $\frac{1}{8}$ the size of the adductor magnus. The semitendinosus is inserted into a point on the tibia $\frac{3}{8}$ths from the head; its origin is low down on the tuber ischii; this muscle is equal to the tensor vaginæ

femoris. The gracilis is very wide; the rectus has two heads as usual, the curved one being made of mixed fleshy and tendinous fibres; the whole extensor mass on the front of the thigh, including the rectus, was indivisible and equalled the psoadiliac in size; the vastus internus was the only part slightly separable.

The popliteus occupied the upper half of the tibia, arising as usual. The gastrocnemius had two heads, an internal, double the popliteus in size, and an external, a little smaller, with which the plantaris was inseparably joined; there was no soleus. The tendon of the gastrocnemius was attached to the heel, that of the plantaris ran into the plantar fascia. There was a single tibio-fibular flexor muscle for the toes which gave off 4 tendons, and equalled the external gastrocnemius in size. The tibialis posticus was very small, and tibio-scaphoid in attachments. The flexor brevis was represented by a few fibres in the plantar fascia. The tibialis anticus was double; one part arose from the tibia, and was inserted into the 1st metatarsal; the other, only half as large, arose from the outer condyle of the femur, by a common origin with the extensor longus digitorum, and was inserted farther forwards.

The synovial membrane of the knee joint made a transversely vertical partition on the plane of this tendon, and the anterior part of the cavity only communicated with the posterior by an opening behind and external to it; this occurs in other animals with a femoral tendon, when that tendon arises anteriorly, as in the Nyl-ghau, Axis, &c., but not when the tendon is very much lateralized, as in Carnivora; then it may not pass through the joint cavity at all.

The extensor hallucis arose from the upper point of trisection of the fibula, and was inserted into the base of the third metacarpal bone; it is very distinct, but very small; the extensor digitorum longus arose from the front of the condyle of femur along with the second tibialis anticus, and was inserted by a fascial expansion into the toes, the slip to the 4th toe being very weak. This muscle equals the second tibialis anticus in size, and is a little larger than the corresponding fore-limb-muscle. The peroneus longus was as usual; the second peroneus is a p. quinti arising from the fibula to be inserted into the outer surface of the 4th toe.

The interossei are smaller in the foot than in the hand, they are as follows: Abductor indicis, Adductor indicis, Abductor medii (tibialis), Abductor medii (fibularis), Adductor annularis, Abductor annularis, Adductor minimi and Abductor minimi; to these is superadded a long adductor minimi digiti, from the ectocuneiform to the inner side of the first phalanx of minimus. (Plate XXVIII., Fig. 4.)

XLIII.—THE MUSCULAR ANATOMY OF THE GORILLA. By ALEXANDER MACALISTER, M. B., M. R. I. A., Professor of Comparative Anatomy in the University of Dublin. (With Plate XXIX., Science.)

[Read June 9, 1878.]

A YOUNG female gorilla was brought home in spirits by Captain J. B. Walker, F. R. G. S., and through the kindness of Mr. T. J. Moore, Director of the Derby Museum, Liverpool, it was sent to Trinity College for dissection. Its examination was conducted with great care by Professor Haughton and myself, and the following are the results of our observations, which are chiefly directed to the myology of the animal.

The occipito-frontalis had two bellies in the gorilla, as in man and the chimpanzee (Annals of Nat. Hist., May, 1871). The orbicularis palpebrarum has its three parts strong; there is no lachrymalis, but the orbital fibres are very distinct; there is a wide, thin tensor tarsi. The basal head of the levator labii superioris alæque nasi is inserted into the alar cartilage; the orbital head is lower, thicker, and wider, inserted into the same cartilage. The levator anguli oris is distinct, and ran downwards and outwards. There was no distinct corrugator supercilii; the zygomaticus is a single wide muscle, as in the chimpanzee. The orbicularis oris was red and thick. The depressor labii inferioris is strong and normal; and the levator menti and depressor labii superioris as are in man.

The masseter is thin, the buccinator is pierced by the Stenonian duct, and a cluster of Wardian glands surround the opening. There is a dilatator naris anterior, but no posterior. There are three muscles for the ear, as usual, a strong retrahens. a wide attollens, and a feeble attrahens. There is a strong ligamentum pterygo-spinosum (Civinini), which is accompanied by a strong muscular band with similar attachments. The rectus capitis anticus minor is stronger than it is in man; the longus atlantis is attached to four vertebræ; the longus colli is as usual, as also are the scalenes and the quadratus lumborum. The omohyoid has two bellies, and is a little stronger than it is in the chimpanzee.

The sternomastoid is to the cleidomastoid as ·11 to ·04. Duvernoy stated that the latter was the larger, but Wyman found it as I did. It is the same in the chimpanzee, in one being as 14 to 6, in another as 19 to 4. The trachelo-acromial was very small and clavicular in its insertion, its origin being atlantic as usual; it only weighed eight grains, and was very small, but larger than in either of my chimpanzees. The trapezius does not extend to the occipital bone, except exactly in the middle line, where there is a fine bundle of fibres passing downwards; it was attached to all the cervical spines, but only ten dorsals, as in the chimpanzee; the insertion occupied the outer third of the clavicle, as well as the acromion and spine of scapula.

The rhomboideus has no occipital origin: its lesser (cervical) part is from three, and its major or dorsal part from four spines, but they are not separable; and the whole muscle is larger than it is in the chimpanzee.

The serratus magnus arose from ten ribs, and its levator anguli scapulæ segment was attached to three cervical transverse processes (4-6); the whole muscle equalled the rhomboid and the trapezius in weight; it is larger proportionally in the chimpanzee, in which the levator segment is more distinctly separable. I could not divide the serratus in the gorilla as I did in the chimpanzee, nor did it extend as far as the twelfth rib in the former, as it did in the latter.

The latissimus dorsi is attached to the spines of the four lower dorsal vertebræ, to the three lower ribs, and to the lumbar fascia. It detached a dorsi epitrochlear element, as a very thin membrane, twenty grains in weight, to be attached to the fascia of the forearm: this is rather larger than in the chimpanzee. The deep spinal muscles are like those of man and the chimpanzee. The deltoid is a single separate muscle as in man, very much larger than in the chimpanzee. The great pectoral has a nearly separate clavicular portion, and so, not like the chimpanzee, it was smaller than the deltoid, while in my chimpanzees it was larger. The lesser pectoral was inserted into the coracoid process on each side, and had no trace of the variability described in this muscle in the chimpanzee (*loc. cit.*); it arose from the third, fourth, and fifth ribs. The subclavius lay under a very strong costo-coracoid membrane, but was exceedingly small. The tendon of the lower pectoral did not split the costo-coracoid membrane.

The supraspinatus was to the infraspinatus as 1 to 2, while in the chimpanzees they were as 10 to 15 and as 11 to 16; teres minor is one-third of the infraspinatus. The subscapularis is large, fully equal in size to the sum of the dorsi-scapular (spinati) muscles—not quite so much in the chimpanzees (27 is to 32). There is no subscapulo-humeral. The teres major is moderate, one-third the latissimus dorsi; it is rather less in the chimpanzees. They are arranged as in man. The coraco-brachialis is the middle variety, like the human normal muscle, and has the musculo-cutaneous nerve superficial to it; it is larger than in the coraco-brachialis.

In the shoulder joint there is a strong gleno-humeral ligament (Plate XXIX., Fig. 2, F. *l.*) and an inferior (Humphry's) ligament.

The biceps has its usual two heads, of which the glenoid was to the scapular as 33 to 18; this muscle is nearly twice as large proportionally as in the chimpanzee. The brachialis is anterior and not external, it equals the glenoid biceps in weight. The three heads of the triceps were more or less combined in the gorilla and chimpanzee. The extensors are to the flexors in the gorilla as 21 to 17. In the chimpanzees they are as 19 to 13. The anconeus is small and distinct. There is no anconeus internus.

In the forearm the pronator radii teres had a coronoid head (Plate

XXIX., Fig. 1) large and distinct, and I found the same in one of the chimpanzees. The flexor carpi radialis is larger than in the chimpanzee. The palmaris longus showed what is not an uncommon human anomaly, viz.:—a flat tendinous origin, an intermediate belly and a round tendon of insertion. This was only an individual variation, as the normal palmaris has been found in other gorillas. I found the same variety in one chimpanzee. The palmaris was rather larger in the chimpanzee than in the gorilla.

The flexor carpi ulnaris had its usual heads, which speedily united; it was one third larger than the radial flexor, while in the chimpanzees they were absolutely equal in three of the four forearms dissected (in the right arm of the first chimpanzee I found the flexor carpi radiali a little larger than the flexor ulnaris). The flexor digitorum sublimis had a radial as well as a condyloid origin, and equalled the combined radial and ulnar carpal flexors; this radial origin is large in one of the chimpanzees, but absent in the other. In one there was no tendon to the little finger, as in Moore's chimpanzee. This muscle is twice as large in the gorilla as in the chimpanzee.

The flexor profundus digitorum, a large muscle, was double the last in weight, and it sent no tendon to the pollex; in it were easily discriminable the germs of the flexor pollicis longus, and of the flexor profundus digitorum. In the chimpanzees it sent off a fine silky tendon to the pollex, and the two muscles were more separable though their tendons were combined. The flexor pollicis mainly supplied the index in the gorilla.

Unconnected with the last muscle, there arose from the fascia over the os magnum and over the trapezium in both hands a flat tendon, which narrowing was attached by one slip to the base of the first phalanx, and by a final expansion into the base of the second phalanx of the pollex; this was evidently the true flexor pollicis longus tendon, and it lay in the inter-space between the two polliceal sesamoid bones.

The pronator quadratus was very small, extending for one-fourth of the forearm, even smaller than in the chimpanzee. The supinator longus is moderate, double the combined pronators, and its tendon was split by the radial nerve. In the chimpanzee it is smaller, not being equal to the pronators; its insertion was as in man, in the gorilla, but on a plane higher, as in the chimpanzee.

The extensor carpi radialis longior is one-half the weight of the brevior. In the chimpanzee they are barely equal, the supinator brevis is one-third the size of the s. longus, yet not quite so large in the gorilla as in the chimpanzee. The extensor digitorum communis is inserted mainly into the second, third, and fourth fingers, and by a very little slip into the fifth; in size it is half that of the flexor sublimis digitorum. The extensor minimi digiti is not only attached to that digit as in the chimpanzees, but by a very slender slip to the fourth; this muscle is one-fourth of the last in the gorilla, only one-sixth in the chimpanzee. The extensor carpi ulnaris is larger than in

the chimpanzee and was attached as usual; there was no ulnaris quinti either in the gorilla or in the second chimpanzee.

The extensor ossis metacarpi pollicis had a double tendon to the trapezium and metacarpal bone, as in the chimpanzee; there was no extensor of the first phalanx, and that of the second was one-third the size of the first named extensor, in the chimpanzee only one-half. —The extensor indicis went to the index finger alone, not to the index and middle, as in the chimpanzees.

The thenar muscles were attached as in man (Plate XXIX., Fig. 3); the abductor pollicis two-headed; opponens, abductor and the two-headed flexor brevis were quite normal. There was an abductor minimi digiti from the pisiform, an opponens from the unciform and a flexor brevis from the same bone. The four lumbricales were radial, as in man, and the palmar interossei were one-headed, adductors for the index, annularis and minimus, together with an extra abductor for the medius. The dorsals were two-headed abductors for the index, medius (radialis), medius (ulnaris), and annularis.

The muscles of the hind limb were; psoas parvus very small, but present as in the chimpanzees. The psoas magnus and iliacus were inseparable, as in the chimpanzees, and were ten times the former in size, very nearly equal in the two species; it extends as high as the fourth lumbar vertebra. The quadratus lumborum is also normal. The gluteus maximus in the gorilla is large, somewhat trapezoidal, separate from the tensor vaginæ femoris and equals in weight the gluteus medius and pyriformis, instead of making $\frac{3}{5}$th of these only, as in the chimpanzee. This muscle is, like all the other muscles of the leg, absolutely much heavier in the gorilla than in the chimpanzee, and has a shorter femoral insertion. The gluteus minimus is mainly marginal, and $\frac{1}{8}$th the size of either maximus, or medius, whereas it is $\frac{1}{4}$th of the medius in one, and twice its weight in the other chimpanzee and $\frac{2}{5}$th of maximus in both. The pyriformis was inseparable in both the gorilla* and one chimpanzee, separate in the other. The tensor vaginæ femoris was one-sixth of the gluteus maximus in weight, and quite separate, whereas in the chimpanzee not only was it united, but it was only about $\frac{1}{10}$th of the maximus. The scansorius was united to the gluteus medius, and weighed with it. So it was in one chimpanzee, but in the other it was attached to the gluteus minimus, and in none was it an absolutely independent muscle. There is an obturator externus, and an internus with two gemelli; these are equal in the gorilla, and nearly so in the chimpanzee. The quadratus femoris equals $\frac{2}{3}$rd of the obturator externus, whereas it is one-half in the chimpanzees.

The abductor primus, or condyloid adductor, is large and distinct; the adductors magnus and brevis are fused together; the adductor

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* It was very rotten in our gorilla, and may have been separate when fresh.

longus is small and separate, and the pectineus only one-half of the last; the whole adductor group of muscles is to the gluteal series as 95 to 100, while in the chimpanzee they are as 86 to 100. The sartorius was normal in all.

The biceps had a perfectly separate femoral head, which was half the weight of the ischiatic; it was much larger in the chimpanzees. The semi-tendinosus had its usual inscription, and exceeded the biceps ischiaticus in size. The semi-membranosus was equal to the femoral biceps in size, thus the inner hamstrings were to the outer as 16 is to 15. The quadriceps extensor differed in no respect from that in man; its rectus element was distinct and two-headed, and formed $\frac{1}{7}$th of the mass; the extensors were to the flexors as 100 to 70, while in one chimpanzee they were as 100 to 56: if we add to these the gracilis, which functionally acts as a flexor, it materially alters the proportion, making it in the gorilla, extensors : flexors : : 100 : 97, that is, practical equality, and in the chimpanzee, ex. : fl : : 100 : 80.

The popliteus muscle had a sesamoid bone or cartilage; it was about as large proportionally as in man. The two heads of the gastrocnemius were inseparable, the internal being a little the larger; in the chimpanzee they are much more separate. The plantaris was absent on both sides, both in the gorilla and one chimpanzee; it was present on the right side of the other, and absent on the left. The soleus was larger than the gastrocnemius (31 : 29) while it was smaller (14 : 17) in the chimpanzee; on the right side there was a trace of a tibial head.

The flexor digitorum longus was ·36, the size of the flexor hallucis; and on separating the united tendons of these muscles in the foot, the fibres of the flexor digitorum were traceable to the 2nd, 3rd, 4th, and 5th digits, while those of the flexor hallucis went to the 1st, 2nd, 3rd, and 4th. In the chimpanzee the flexor digitorum is one-half the size of the flexor hallucis, and it supplies the 2nd, 3rd, and 5th digits, while the flexor hallucis supplied the first, third, and fourth.

The tibialis posticus was a strong muscle, inserted as usual into the scaphoid and ento-cuneiform, but it sent a slip to the head of the third metatarsal bone. This I did not find in the chimpanzee. The flexor digitorum brevis was strong, and sent no slip to the little toe; the accessorius was small and oblique. The tibialis anticus was double, one half going to the ento-cuneiform, the other, which was only $\frac{1}{8}$th the size, was inserted into the metatarsal bone of the hallux. In the chimpanzee it is the same.

The extensor hallucis proprius is a distinct oblique muscle, much larger than the corresponding muscle in the chimpanzee, and arising as usual from the middle of the fibula. Extensor digitorum longus is not much stronger, and sends off four tendons to the outer toes; the flexors of the toes are to the extensors as 3 : 1. In the chimpanzee they are in the same proportion. The peroneus longus is weaker than the brevis (double it in the chimpanzee); the peroneus quinti exists as a tendon in both; there is no peroneus tertius.

The abductor hallucis is large and has two heads; there is a flexor brevis, an adductor (transversalis pedis), with heads from the 4th and 3rd metatarsal bones, and an opponens, inserted into the metacarpal bone. There is an abductor minimi digiti, a flexor brevis, and an adductor. The foot interossei are like those in the hand, but there is no second or plantar abductor for the medius, as existed in the hand.

XLIV.—The Muscular Anatomy of the Civet and Tayra. By Alexander Macalister, M. B., M. R. I. A., Professor of Comparative Anatomy in the University of Dublin.

[Read June 23, 1873.]

This Paper is based on the dissection of a large Civet Cat (Viverra Civetta), and a Tayra (Galera barbata), of Brazil, both of which died in the Zoological Gardens.

The exoskeletal muscular system in the Civet was well marked, the nuchal platysma running nearly transversely, with a little inclination forwards, the axillary and abdomino-femoral being as usual. The trapezius is threefold—the first arising from the middle line of the neck, from the occiput to the fifth cervical spine, it joins the cleido-mastoid along the clavicular inscription, and is continued into the scapular deltoid. The superior scapular trapezius arises from the fascia of the middle line of the neck from the fifth cervical to the second dorsal spines, and is inserted into the upper border of the spine of the scapula. The inferior scapular trapezius passes from the five upper dorsal spines to the inferior border of the scapular spine, as far as the tubercle of Retzius. In the Civet the clavicular portion equals the entire scapular; they are 0·54, 0·22, 0·27 respectively.

The sterno-mastoid in the Civet arose along with its fellow, to which it is united for two-thirds of the length of the neck in the mesial line; they then diverge, and the insertion is round and fleshy. It does not unite above with the trapezius, whose clavicular part it exceeds (=0·64). Cleidomastoid is quite separate, not in contact with its fellow, and underlies the sterno-mastoid above; its origin is from the tendinous inscription; its insertion is into the paroccipital process by a tendon. The spinal accessory nerve separates these two. Cleido-mastoid = 0·19. In Galera its insertion is into the paramastoid, and it is pierced by the spinal accessory nerve.

Rhomboideus extends in the Civet as a continuous sheet from the third cervical to the fourth dorsal spine, and weighs 0.45. In Galera there is an occipital slip, and a separate slip external to it from the transverse process of the atlas to the prescapular base. These are quite separate at origin, but are inserted together; the rest of the rhomboid stretches from the last one or two cervical, and uppermost three dorsal spines.

Acromio-trachelian arises from the transverse process of the atlas and from the tendon of insertion of the outer part of the longus colli. It is inserted remote from the rhomboid, at least 2·1 inches from it; it weighs 0·28. In Galera it is normal, and has no second origin; its insertion is into the root of acromion, and the fascia over the shoulder.

Splenius in both is large, thin, and arises from the six lower cervical spines; its insertion is occipital. The trachelo-mastoid arises from the transverse process of the lowest four cervical vertebræ, and the first dorsal, and it is inserted into the paroccipital; it has one inscription. The complexus has also an inscription, and arises from the transverse process of the 4-7 cervical, and 1-2 dorsal. The other muscles are normal; the obliquus capitis inferior being the largest in all. The rectus capitis posticus major is double, one part being thin and triangular, and the second stronger. The rectus minor is normal. The rectus capitis lateralis is close to the obliquus superior. The first intertransversalis muscle is very oblique, passing upwards and outwards to the atlas, parallel to the outer border of the obliquus inferior.

Serratus posticus extends from the 4th to the 11th ribs. Transversalis colli stretches from the longissimus dorsi to the 4th and 5th cervical transverse processes. Cervicalis ascendens passes from the 1st-5th ribs to the four lower cervical transverse processes.

Spinalis colli, and the deeper muscles, were as usual in Carnivores.

Sterno-hyoid is normal, with an inscription, its origin being attached to that of sterno-thyroid in Civet, but separate in Galera. There were no omohyoids. The digastric was thick, with an oblique inscription, and a posterior insertion into the hinder half of the mandible. The hyo-glossus was normal, weak, with a slip from the epihyal in Galera; the stylohoid thin, flattish; the stylo-glossus arose from the middle of the stylohyal, and was wide. In Galera there was a mastohyal from the para-mastoid process to the stylohyal bone, and a thyro-cerato-epihyal from the thyrohyal cornu to the cerato- and epihyal bones. The thyrohyoid muscle stretches forwards and inwards; the cricoid cartilage is incomplete in front in Galera. There are three constrictors to the pharynx, and an isthmus exists for the thyroid body; crico-arytænoideus posticus is large, and arytænoideus proprius very small.

The superficial ear muscles are retrahens, which arises by two slips from the occipital crest and fascia, to be inserted into the back of the concha. A transversalis nuchæ (F. E. Schulze) very wide, and connected with the nuchal platysma, lies over this, and is also attached to the back of the concha. The masseter is very large, and extends as far back as the point of the spur of the mandible. A part of the temporal muscle arises posteriorly above the tympanic and root of the zygoma, and passes forwards and a little upwards to be inserted into the point of the coronoid process of the lower jaw. There is no uvula in either, and a long velum in both.

The acromial deltoid is small, and arises from the top of the acromion (0·12). The clavicular is much larger, arising from the clavicular inscription, where it blends with the cleido-mastoid and clavicular trapezius (0·54). The scapular is much smaller (0·09), arising from the middle third (Galera, or half, Civet) of the spine of the scapula, and inserted the highest up of all, under the acromial part. The clavicular part is inserted partly into the brachialis anticus, and partly into the humerus (Galera), or into the radius (Civet).

Supraspinatus was in two parts in the Civet, one from the epiphysial element of the prescapula, the other weaker from the upper surface of the spine; it exceeded infraspinatus by about $\frac{1}{4}$ (supraspinatus = 0·34).

Teres minor arose from the anterior third of the scapular border, and was quite distinct in the Civet. In Galera it is very short, and its nerve has no ganglion; its tendon of origin is slightly connected to that of the long head of the triceps.

Subscapularis is weak (0·35), with three sets of fibres; a middle, with a tendon in front; a supra-marginal, and an infra-marginal. In the Galera there are four slips, of which the inferior (subscapulo-humeral) is the most detached and fleshy; none of the capsular muscles pierce the shoulder joint.

Serratus magnus arises from 4–7 cervical vertebræ and 1–7 ribs in Civet (8 in Galera). It has nothing remarkable about its lower border, nor has it any anomalous relation to the rhomboid, where the prolonged scalenus posticus lies in front of it. It does not extend far forwards.

Scalenus anticus is small, and passes from the sixth cervical transverse process to the first rib. S. medius arises from the 3rd–6th vertebræ. Scalenus posticus passes from the 4th–6th vertebræ to the 3rd–6th ribs inclusive. The rectus abdominis in Viverra is inserted into the whole length of the mesosternum and by tendinous fibres into the presternum. There are seven inscriptions in Viverra, six in Galera, in which the muscle is attached to the first rib. The external oblique in the latter arises from the 5th–14th ribs.

The great pectoral consists of four laminæ; 1st. Presterno-humeral, slender, transverse, and with no fibres common to its fellow of the opposite side. This in Galera is distinct, and less superficial. 2nd. Anterior meso-sterno-humeral passed from the first and second sternebers, to be inserted at the lowest point of the pectoral crest of the humerus; the posterior meso-sterno-humeral arises from the 2nd to the 5th sternebers, is inserted into the upper part of the pectoral crest. 4. The xiphisterno-humeral is slender, and inserted into the fascia over the origin of the biceps, beneath the others. These parts in the Civet are to each other as the following proportions:—0·13, 0·37, 0.96, 0·16.

The fourth pectoral, or the brachio-lateral part of the panniculus, is large and extensive, and is inserted into an "achselbogen," closely tied to the humerus.

There is no true pectoralis minor; but there is a subclavius, very small from the first rib to the inscriptive clavicle.

Latissimus dorsi arises from 5th to the 16th trunk spines (Viverra), or 3rd to the 13th (Galera). It was very large (1.49); the teres major, attached to it at its insertion, weighed 0·22. In Galera the teres is inserted into the front of the latissimus dorsi tendon, a little of it going into the bone directly above the tendon. There is a well-marked dorsi-epitrochlear in the Civet, and in the Galera there are two, one of which arises from the brachio-lateral panniculus, not from the latissimus dorsi, and the other from the angle of the scapula; this second part is the stronger of the two.

Coraco-brachialis is a C. brevis in the Civet (0·02), and has its usual long tendon of origin; it passes into the upper edge of the latissimus dorsi, and teres major tendons, and into the bone. On the right side of my Civet it went wholly into the teres major. In the Galera there is a coraco-brachialis longus arising by a tendon from the coracoid. This ends in a pyriform belly, overlying the external cutaneous nerve. The insertion is into the lowest part of trisection of the humerus; the nutritious artery pierces the bone at its insertion, and in this specimen sent one branch upwards and one downwards.

The triceps longus is not very large in Galera, and the humeral heads are quite distinct; there is a wide anconeus externus. In Viverra the long head is large (0·95), and arises from the entire axillary costa of the scapula. The inner is very small from the internal ridge (0·07); the outer is larger (0·51). A second inner head arise from the pit beneath the head of the humerus, and this joins the long head at the elbow. A short flat anconeus externus arises from the flat space above the elbow joint, and is mainly inserted into the synovial membrane; it underlies the outer head of the triceps in both, and weighs 0·05.

Brachialis anticus is strong and fleshy (weighing 0·17), and external as usual; its insertion is ulnar.

The biceps arises from the extremity of the coracoid by its long tendon; there is no second head, and its insertion is radial.

Supinator radii longus is well marked (0.05), inserted into the lower end of the radius with a slip into the dorsal carpal ligament; it is proportionably larger in Galera. The radial extensors of the carpus are partly separable below. The longus = 0·05; the brevis 0·09. The supinator brevis was well marked in both. Extensor digitorum communis = 0·05, went to all the digits, the extensor minimi digiti went to the 3rd, 4th, and 5th digits. The extensor carpi ulnaris was large 0·10, and had a flat tendon inserted as usual, with no prolonged slip.

The extensor ossis metacarpi pollicis arrives as far as the olecranon process, and is inserted into a fabella at the base of the first metacarpal bone; in Galera a second tendon goes to the trapezium (0·08), another fabella lies internal to it in the anterior annular ligament. Extensor pollicis et indicis is slender but long (0·02), arising

from the ulna and having passed in a special sheath over the radial extensors of the carpus inserted as usual by splitting into two a weak expansion for the index and a more definite tendon for the pollex.

Pronator radii teres has a condyloid origin, and in Viverra is inserted just above the middle of the radius, it weighs 0·07; in Galera the pronator is inserted into the lower half of the radius.

Palmaris longus is pisiform (0·05), rather larger in Galera.

Flexor sublimis digitorum is very small (0·02), arising from the front of the tendon and belly of the flexor profundus, and its tendons splitting are inserted into the sheaths of the tendons in the fingers.

Flexor carpi radialis is condylo-deuto-metacarpal as usual, and weighs 0·06 in the Civet. Flexor carpi ulnaris is in two quite separate parts, one condyloid and weighs 0·13, the other olecranal, (0·03), these unite at their pisiform insertion, the whole muscle is quite separate from the flexor profundus digitorum.

The flexor profundus consists as usual of its four parts, condylo-ulnar, condylo-radial, radial, and ulnar parts, which weigh respectively 0·19, 0·03, 0·03 and 0·04, these supply the five digits.

The pronator quadratus occupies the lower one-fourth of the fore-arm (0·07), and is crossed by a vertical radio-carpal fascial band in place of a radio-carpeus muscle. There are three lumbricales in the Civet, there being none for the fifth digit. The abductor pollicis arises from the palmar fabella, is a small pyriform muscle with a long delicate tendon. The flexor brevis pollicis has two heads, there is no abductor pollicis, and a small opponens. There is an abductor minimi digiti from the front of the annular ligament and pisiform, and a deeper separate abductor (or flexor) from the inside of the fifth meta-carpal bone, inserted into the ulnar sesamoid bone of the little finger; this is supplemented by a small fleshy belly from below the two vin-cula of the pisiform bone, and the two uniting form a tendon which is inserted into the first phalanx. A second flexor brevis minimi digiti arises from the unciform, and is inserted beside the last. The palmar interossei are: first, a (carpally arising) adductor indicis; second, a (metacarpal) adductor indicis; third, an adductor annularis; fourth, an adductor minimis digiti. The dorsal, are: first, abductor indicis; second, abductor medii; third, adductor medii; fourth, adductor annularis; these are all bicipital except the third. Flood's and Humphry's ligaments are strong in the shoulder.

Sterno-costalis passes from the upper sternebers to the first rib, its origin is tendinous. Psoas parvus arises from the 3–5 lumbar vertebræ and the margin of the ilium.

Agitator caudæ arises from the first and second caudal vertebræ, and is inserted into the back of the femur (0·27). Gluteus maximus, quite separate, arises from the fascia over the posterior half of the gluteus medius, and from the first and second caudal vertebræ it is inserted into the femur on its outer side into the line prolonged from the great brachiales for nearly half way down (0·25). Tensor vagi-

næ femoris (0·24) is above the last, and arises from the anterior superior spine and fascia behind it, reaching to the gluteus maximus, from which it is only artificially separable in the Civet. In Galera they are quite separate, the tensor only arising from the iliac spine, and a short way behind it, while the gluteus was mainly caudo-sacral in origin, the crurales are very wide into the femur and fascia.

Gluteus medius is thick and strong (0·67), the pyriformis is inseparable in Galera, very separate in the Civet (0·13), and arises from the fronts of third sacral and first caudal vertebræ.

The gluteus minimus is very small (0·04), and posterior, the gluteus quartus arises in front and below a very distinct antero-posterior ridge in the dorsum ilii (0·05). A gluteus quintus arises from the front of the brim of the acetabulum, over the curved head of the rectus femoris, and passing downwards and backwards is inserted into the anterior intertrochanteric line, separated from the iliacus by the rectus femoris; there is no fifth gluteus in Galera. The coccygeus is large and wide (0·11), the depressor caudæ is very large and arises behind the last and in common with the hinder fibres of the levator ani.

There are two strong gemelli inserted beneath the tendon of the obturator internus (0·16), as well as a very strong obturator externus (0·14). There is a special sphincter for the scent glands.

The rectus has two heads as usual (0·54), and the gracilis is thick and wide (0·41). The vastus externus = 0·94, the vastus internus and crureus = 0·43.

The sartorius in the Civet is double, the first arising above and behind the anterior superior spine, and inserted into the patella = 0·38, the second arises normally below the last and is inserted into the fascia on the inner side of the knee and over the inner side of the fibula, it weighs 0·19. Galera has but one sartorius, which is very wide and flat, its attachments comprise those of both parts in the Civet. Semi-tendinosus has a tendinous intersection at the point where its ischiatic and its caudal (from second caudal vertebra) head unite, it is not prolonged to the heel, and weighs 0·57. Semi-membranosus (0·42) is thick and fleshy, not attached to the superficial fascia of the leg but to the inner condyle of the tibia, it is quite separate from the adductor primus in the Galera, not so in Viverra.

The biceps (1·05) arises by a narrow ischiatic origin, and is inserted into the upper two-thirds of the outer side of the leg, its insertion is all tendinous. Bicipiti accessorius is a very delicate strap (0·04), with a tendinous origin from the fascia at the base of the tail and the third caudal transverse process; in the Civet it receives a slip from the semi-tendinosus at its insertion.

Pectineus is small, normal (0·01). There is a ligamentum teres, and a strong ilio-femoral accessory ligament. The adductor primus is attached to semi-membranosus as in the Civet, and weighs 0·44, the A. secundus is separable into two planes in the Civets ($\alpha = 0·75$, $\beta = 0·47$), but they are inseparable in the Tayra. Adductor longus = 0·06, in

Galera it is inserted very high up in front of pectineus and down as far as the middle third of the thigh.

Quadratus femoris is very large and normal, 0·07. Gastrocnemius externus has a fabella, and is almost separate from the plantaris, the gastrocnemius internus has a fabella in Viverra, but none in Galera. The plantaris arises from the external fabella, and from the condyle above it, and is here only slightly joined to the gastrocnemius externus muscle, its tendon passes that of the gastrocnemius and is inserted into the plantar fascia.

The soleus is quite separate, arising from the head of the fibula and is inserted into the upper part of the os calcis.

The popliteus has a cartilaginous fabella, and is attached to one-third of the back of the tibia.

Tibialis anticus is large, single, and inserted into the metatarsal bone of the hallux.

Extensor digitorum communis is large, tendinous and femoral in its origin as usual, and inserted by four tendons into the four outer digits, the belly divides into two parts, of which one goes to the second, third, and half of the fourth digit, the other to half of the fourth and fifth, the two slips to the fourth unite on the dorsum of the foot.

Extensor hallucis proprius is slender, and arises from the upper half of the margin of the fibula, and is inserted solely into the hallux.

Peroneus longus sends a tendon to the posterior part of the floor of its own groove in the os calcis, and is inserted into the fifth and first metatarsal bones.

Peroneus brevis is normal, and peroneus quinti is as usual, and quite separate in both.

Tibialis posticus is fleshy, and mostly fibular and membranous in origin, it is inserted into the scaphoid bone; in Galera it arises only from the heads of fibula and tibia.

The flexor longus digitorum is as usual tibial, and the flexor hallucis fibular and much larger; the two tendons unite, and are inserted into the five toes; there is a strong accessorius from the outer side of the calcaneum, and three lumbricales, none existing for the index.

The muscles of the sole are flexor brevis hallucis from the entocuneiform to the outer sesamoid, flexor brevis digitorum from the plantaris tendon to the three middle toes, there is a perforated tendon for the little toe, but it does not arise from this muscle, and is only connected to the plantar fascia.

Adductor hallucis is calcaneo-halluceal, adductor is from the meso-cuneiform, abductor and flexor brevis minimi digiti are as usual.

The interossei muscles are as follows:—

First plantar, an adductor indicis.

Second plantar an adductor annularis.

Third plantar, an adductor minimi digiti.

All these have single heads. In Galera there is a deeper adductor indicis quite separate.

First dorsal, an abductor indicis.
Second dorsal, an abductor medii.
Third dorsal, an adductor medii.
Fourth dorsal, an abductor annularis.

All of those had two heads but the second.

There is an abductor ossis metatarsi minimi digiti in both.

The decimals appended to the muscles are fractions of an ounce avoirdupois, and refer to the muscles of the Civet.

XLV.—ON THE QUESTION OF CHEMICAL EQUILIBRIUM. By the REV. J. H. JELLETT, B. D., S. F. T. C. D., PRESIDENT.

[Read November 30, 1873.]

THE determination of the law according to which an acid divides itself between two bases which are present in the same solution has been long known to be one of the obscure questions of Chemistry. It is generally admitted by Chemists that there is a division, and that the relative masses of the two bases exercise an important influence upon the law which governs it. But the law itself is unknown. The object of the present paper is, to give at least a partial solution of this problem.

The author proposes to treat the question as one of *Chemical Equilibrium*, defining these terms as follows:—

Two or more substances may be said to be in chemical equilibrium if they can be brought into chemical presence of each other (as in a solution), without the formation of any new compound, or change in the amount of any of the substances which are thus brought together.

If now an acid be added to a mixture of two bases, the result will in general be that four substances will be present in the solution, namely, two salts, and two portions of bases remaining uncombined. It is evident that these four substances are in chemical equilibrium. The question, then, which arises is this:—What relation, or relations, must exist between these four substances? In the language of Mechanics, what is the equation (or equations) of equilibrium?

The author showed that there can be but *one* equation of equilibrium, inasmuch as the quantities of the four substances which are present in the solution are functions of *three* independent variables, namely, the original quantities of each base (2), and the original quantity of acid (1), these quantities being, within certain limits, arbitrary.

Denoting by B_1 B_2 the quantities of free base, and by S_1 S_2 the quantities of each salt respectively, the equation of equilibrium is necessarily of the form

$$U = F(B_1, B_2, S_1, S_2) = O.$$

The object of the present investigation is to determine the form of the function F.

The bases selected for experiment were quinia and brucia. These alkaloids possess in solution, as is well known, the power of rotating the plane of polarization of a transmitted ray. It is known, moreover, that in the case of quinia the rotatory power of any of its salts *exceeds* the rotatory power of the base, while in the case of brucia the rotatory power of the salt is *less* than that of the base.

These facts being premised, the mode of investigation may be described as follows:—

First Experiment.

One of the tubes of the saccharometer is filled with a solution containing quinia and brucia, to which has been added a quantity of hydrochloric acid, insufficient to convert the whole of both bases into salts. The other tube is filled with the same solution diluted with a certain amount of the solvent used (proof spirit).

The actual rotation being determined for each, it is found that that caused by the second fluid is less than that caused by the first, in the exact ratio of the dilution. Hence it may be inferred that *equilibrium is not troubled by dilution.*

For such disturbance could only arise either by a transference of a certain quantity of acid from the quinia to the brucia, or *vice versa* by a transference of acid from the brucia to the quinia. But it is evident that either transference would alter the rotation. The former would substitute for a certain portion of hydrochlorate of quinia a corresponding quantity of free quinia, thus diminishing the rotation, and for a quantity of free brucia a corresponding quantity of hydrochlorate of brucia, thus further diminishing the rotation. The second transference would evidently augment the rotation. If then the rotation undergo no change but that caused by the dilution, it is plain that there is no transference, or, according to the definition, no rupture of equilibrium. Equilibrium depends, therefore, only on the *ratios* of the four substances. Hence

$$U = F\left(\frac{B_1}{{}_1S}, \frac{B_2}{S_2}, \frac{B_1}{B_2}\right).$$

Second Experiment.

A solution is prepared, containing quantities (carefully measured), of quinia and brucia. To a given bulk of this is added a certain quantity of hydrochloric acid, insufficient to neutralize both basis. The tubes of the saccharometer are filled, one with the unacidulated mixture, the other with the acidulated mixture.

Putting now

r_1 = rotatory power of quinia.
r_2 = rotatory power of brucia.
ρ_1 = rotatory power of hydrochlorate of quinia.
ρ_2 = rotatory power of hydrochlorate of brucia.
r = actual rotation for acidulated mixture.
a = total amount of acid corresponding to the unit of bulk of solution.
x = amount which combines with the quinia—

it is easily seen that

$$r = \frac{\beta_1 x}{a}\rho_1 + \left(b_1 - \frac{\beta_1 x}{a}\right)r_1 + \frac{\beta_2 (a-x)}{a}\rho_2 + \left(b_2 - \frac{\beta_2 (a-x)}{a}\right)r_2$$

where β_1, β_2, a are the atomic weights of the two bases and the acid respectively, and b_1, b_2, are the quantities of each base contained in the unit bulk of the solution.

Solving this equation for x we have

$$x = Aa + B\,(r - b_1 r_1 - b_2 r_2),$$

where

$$A = \frac{\beta_2 (r_2 - \rho_2)}{\beta_1 (\rho_1 - r_1) + \beta_2 (r_2 - \rho_2)}$$

$$B = \frac{a}{\beta_1 (\rho_1 - r_1) + \beta_2 (r_2 - \rho_2)}.$$

These constants are to be determined by a separate series of experiments. If r_0 be the actual rotation caused by the unacidulated mixture, it is evident that

$$r_0 = b_1 r_1 + b_2 r_2.$$

The foregoing equation may, therefore, be written :—

$$x = Aa + B\,(r - r_0).$$

This equation gives the quantities of acid, x and $a - x$, which are taken by the quinia and brucia respectively.

Third Experiment.

A solution of quinia is acidulated with such an amount of hydrochloric acid, that the quantity of the base which remains uncombined shall bear to the acid the same ratio as exists in the foregoing mixture between the uncombined quinia and the quantity x. A solution of brucia is similarly acidulated so as to preserve the ratio of the uncombined brucia to $a - x$. It is plain then that in these acidulated solutions respectively the ratios of B_1 to S_1, and of B_2 to S_2 are the same as in the case of equilibrium. The rotations caused by these fluids being R_1 and R_2 respectively, let them be mixed in any proportion, and let the rotation caused by the mixture be observed. Then, if the proportion in which they have been mixed be $m:n$, it is found that the rotation caused by the mixture is

$$\frac{mR_1 + nR_2}{m+n}.$$

It is easily inferred then as before, that there is no rupture of equilibrium in this mixture, whatever be the ratio $m:n$. Hence it is evident that if the ratios $B_1 : S_1$ and $B_2 : S_2$ have the values proper for equilibrium, this latter will be preserved, however the ratio $B_1 : B_2$ may vary. Hence, in mathematical language

$$U = F\left(\frac{B_2}{S_1}\frac{B_1}{S_2}\right).$$

Fourth Experiment.

A mixture of solutions of quinia and brucia is made, in which these bases have to each other the same ratio as the uncombined bases in the second experiment. A second mixture is made of the same solutions, in which the bases have the same ratio as the combined bases in the second experiment, and a sufficient quantity of hydrochloric acid is added to the second mixture to convert the whole of both bases into salts. Hence it is evident that the ratios $B_1 : B_2$ and $S_1 : S_2$ in these mixtures, respectively, have the values required for equilibrium. If now, as before, these two mixtures be added to each other in the proportion $m : n$, it is found that the rotation caused by the mixture is

$$\frac{mR_1 + nR_2}{m+n},$$

R_1, R_2, being the rotations caused by each of the added fluids separately. We infer then in the same way as before that

$$U = F\left(\frac{B_1}{B_2}, \frac{S_1}{S_2}\right)$$

But if U satisfy both these conditions it is easily shown mathematically that

$$U = F\left(\frac{B_1}{S_1} \div \frac{B_2}{S_2}\right)$$

Hence it is evident that the required equation of equilibrium is

$$\frac{B_1}{S_1} \div \frac{B_2}{S_2} = \text{const.}$$

or

$$B_1 S_2 = K B_2 S_1.$$

This law may be otherwise stated thus :—

Let a_1, a_2, be the quantities of hydrochloric acid combined with the quinia and brucia respectively. Then we know that S_1, S_2, are respectively equal to a_1, a_2 multiplied by constant quantities. Hence,

If to a mixture of quinia and brucia there be added a quantity of hydrochloric acid insufficient to convert the whole of both bases into salts, the products made by multiplying the uncombined portion of each base with the portion of acid combined with the other base, have to each other a constant ratio.

The author showed the bearing of this law upon the theory stated by Professor Williamson, that chemical combination is not statical, but dynamical, observing that this theory is quite in accordance with the result which he has obtained. It would be, on the other hand, difficult to reconcile the statical conception with this result, or even with the fact that there can be but one equation of equilibrium.

XLVI.—ON THE MYOLOGY OF THE GENUS BRADYPUS. By H. W. MACKINTOSH, B. A.

[Read November 10, 1873.]

THROUGH the kindness of Dr. Macalister, Professor of Comparative Anatomy and Zoology in the University of Dublin, I had the opportunity of being present during the dissection of a fine specimen of Arctopithecus Blainvillei, and on the notes of that examination, together with reference to the former dissections of Bradypus tridactylus by Professors Macalister* and Humphry,† the following paper has been compiled.

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* Annals and Magazine of Natural History, July, 1869.

† Journal of Anatomy and Physiology, 2nd series, No. 5, Nov. 1869.

The incidental allusions to Meckel's* dissection of the Aï are taken from Professor Macalister's paper. The weights of the principal muscles, which are given in decimals of an ounce, afford an easy means of comparison:—

In the head:—

Masseter arises from the anterior and posterior surfaces of the descending jugal process and runs backwards to the usual mandibular insertion. The internal pterygoid is large, but there is no external pterygoid.

The following points of general anatomy are worthy of notice: the parotid gland is well developed and lobulated, the sublingual and submaxillary are absent; the tongue is devoid of a cartilaginous septum; the œsophagus lies well to the left of the trachea, which is coiled up in an S curve on the left lung, which is decidedly the larger of the two; there is the usual rete mirabile in the axilla, and a very large one in the course of the femoral artery.

In the fore limb:—

Trapezius arises from the spines of the lower five cervical vertebræ and from those of the upper five dorsal; it is inserted into the scapular spine for half its length, into the coracoid and acromion processes, and into the rudimentary clavicle; it was not divisible into parts. Professor Macalister found the origin from all the cervicals except the atlas, and from the six upper dorsals, but there was no clavicular insertion; however, this is described by both Professors Humphry and Meckel, the former remarking that the cervical portion is scarcely traceable to the skull, and that its hindmost fibres are continued into those of the deltoid.

Rhomboid is (·05) a small muscle arising from the eighth and ninth cervical, and four upper dorsal spines, and inserted in the usual way. There was no occipital prolongation either in our specimen or in B. tridactylus, but the origin in the latter was more limited, only extending from the last cervical to the third upper dorsal.

Trachelo-acromial is absent in all.

Serratus magnus (·02) had no distinct levator scapulæ portion, either in our specimen or in Professor Macalister's; that part of the muscle corresponding in position to levator scapulæ arises from the transverse processes of the seventh, eighth, and ninth cervicals, and is inserted into the usual place. Professor Humphry says that the levator scapulæ is distinct from the serratus, arising from the sixth, seventh, eighth, and ninth cervical transverse processes, and inserted

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* System der Vergleichenden Anatomie, 1828. Meckel's specimen seems to have been Arctopithecus Blainvillei, since it agrees almost exactly with our individual whilst differing considerably from Bradypus tridactylus. The animal described above was sent over here by the Rev. J. M'G. Ward, Chaplain to H. M. S. Egmont, from Rio de Janeiro, under the care of Dr. Armstrong, being intended for the Royal Zoological Society's Gardens. It died, however, shortly after its arrival in Dublin, and was given by Dr. Armstrong to Dr. Macalister for dissection.

into the upper part of the base of the scapula quite separate from it. The part corresponding to serratus magnus arises from the seven upper ribs, and is inserted into the whole length of the vertebral edge of the scapula. Professor Macalister gives its origin from the upper eight ribs, and its insertion into the lower two-thirds of the edge of the scapula; Meckel's description agrees with ours, whilst Professor Humphry states that it is in two parts, the anterior extending from the first and second ribs to the superior angle of the scapula, and the posterior arising from the third to the eleventh ribs, and inserted into the under surface of the inferior angle of the scapula.

Splenius is described by Professor Macalister as "distinct, moderate in size, arising from the spines of the third, fourth, fifth, and sixth cervical vertebræ, and inserted into the transverse process of the atlas; this part seems to correspond with the splenius capitis of other animals, but has no occipital attachment; the second part, or splenius colli, arises from five spines below the last named muscle, and is inserted into the transverse processes of the second, third, fourth, and fifth cervical vertebræ."

Complexus arises from all the cervical transverse processes, is inserted into the occipital bone, has no biventral portion and no tendinous intersections (Professor Macalister).

Scalenus anticus arises from the third, fourth, fifth, and sixth cervical transverse processes, and is inserted into the first complete rib. Scalenus posticus arises from the corresponding processes of the sixth and seventh cervicals, and is inserted into the last cervical rib. The intercostal muscles extend from the last cervical to the first true rib.

Semispinalis colli, longissimus dorsi, spinalis dorsi, ilio-costalis, musculus accessorius ad ilio-costalem, multifidus spinæ, rectus capitis anticus major (origin, sixth, seventh, and eighth cervical vertebræ in Arctopithecus), rectus capitis posticus major and minor, obliquus capitis superior and inferior (the latter large in Arctopithecus), rectus capitis lateralis, longus colli (large in B. tridactylus), were all normal; rectus capitis anticus minor in Arctopithecus was made up of two parts, the inner smaller one from the first cervical, the other from the usual place, both had the normal insertion. The interspinales extend into the tail.

Sterno-cleido-mastoid arises under the tendon of the pectoralis major, and is not mesially connivent in Arctopithecus, a condition found by Professor Macalister, who describes the origin from the front of the sternum, slightly from the first rib and very slightly from the inner end of the clavicle; it is inserted by two slips into the paramastoid process. It will be observed from this that the muscle is properly speaking a sterno-mastoid in Arctopithecus.

Thyrohyoid, hyoglossus, and genioglossus, were all normal; geniohyoids were united in the middle line to form a single muscle in Arctopithecus; sternohyoid and sternothyroid were united, the latter part being the largest and the origin broad in our specimen, separate and normal in B. tridactylus. Digastric univentral, with a distinct in-

scription, takes origin from the tympano-hyal above the hypoglossal nerve, and is inserted as usual. Mylohyoid is transverse for nearly the whole length of the mandible. Styloglossus arising from the stylohyal arch passes forwards, overlying the hypoglossal nerve, and subjacent to the digastric muscle to be inserted as usual.

Pectoralis major (0·42) bilaminar, the superficial portion taking origin from the front of the sternum, from the cartilages of the seven upper ribs, very slightly from the inner end of the clavicle, and continuous across the sternum with its fellow of the opposite side, runs forwards and outwards to be inserted into the second fourth of the pectoral crest of the humerus; the deeper part with the same origin, is inserted into the upper third of the pectoral crest, is more tendinous, has its fibres more horizontal, and sends an upper slip to the capsule of the shoulder joint. Professor Macalister found its origin to be from the front of the sternum, from the cartilages of the six upper ribs, and distinctly from the inner end of the clavicle, the insertion was the same as in Arctopithecus, a condition which also existed in Professor Humphry's specimen, in which the origin was so mutilated as to be indistinguishable.

Pectoralis minor is absent, as was also the case in the specimens dissected by Professors Macalister and Meckel. Professor Humphry describes it as arising "from the second, third, fourth, fifth, and sixth costal cartilages close to the sternum. The fibres converge to a tendon which is quite distinct from that of the pectoralis major, and is inserted above it into the outer tubercle of the humerus," and remarks that it exists as represented by Cuvier and Laurillard. Professor Macalister however, considers that Cuvier's pectoralis minor is really a subclavius.

Subclavius (·02), arising from the first rib (in all), and passing outwards and upwards, is inserted into the clavicle and coracoid (Arctopithecus); into the under side of the acromion process, and by a few fibres into the clavicle (Professor Macalister); slightly into the under surface of the clavicle but chiefly into the inner edge of the coracoid process (Professor Humphry).

Pectoralis quartus (·05) takes origin from the sixth, seventh, eighth, ninth, and tenth ribs, and is inserted into the top of the pectoral crest. Professor Macalister found it extending from the seventh and eighth ribs to the outer lip of the bicipital groove, and Professor Humphry describes it under the name of brachio-lateralis as being attached to the upper part of the pectoral crest, passing backwards under the pectoralis major, closely connected with the seventh rib but mostly passing over it, expanding on the rectus and obliquus abdominis, and finally lost in the fascia about the knee.

Sternocostalis arises from the fifth, sixth, and seventh ribs, and is inserted into the first rib. Professor Macalister describes it under the name of rectus thoracicus lateralis, as arising from the third, fourth, and fifth ribs, and inserted as above. Professor Humphry reverses our description of this muscle, giving its origin from the first rib, and its

insertion into the seventh and eighth, and considers it to be an extension backwards of scalenus.

Latissimus dorsi (·4 + panniculus carnosus) arises from the lumbar fascia over the lower dorsal spines, and from the fifth to the twelfth ribs (lower five, Professor Macalister), and has the usual insertion into the humerus, quite separate from teres major.

Deltoid (·22) is not at all divisible, and has a very extensive origin from the acromion process, half the scapular spine, coracoid, and a small part of the clavicle; it is inserted into nearly the entire upper half of the humerus, giving off an accessory head to the biceps, as is noticed by Meckel, a condition which was not found by Professors Macalister or Humphry. The former anatomist describes the deltoid as taking origin from the acromion, and entire scapular spine, and being inserted into the middle fourth of the humerus. In Professor Humphry's specimen the origin was coracoidal closely connected with the biceps.

Supraspinatus (·1) is normal in all, with a very wide tendinous attachment to the capsule of the shoulder joint in Arctopithecus.

Infraspinatus (·1) is also normal in all, and teres minor is absent in our specimen and that of Professor Macalister, who observes that the muscle described under that name by Meckel seems to be a subscapulo-humeral; Professor Humphry, however, says that it was quite distinct and separate from the deltoid in his specimen.

Subscapulohumeralis (·04) arises from the upper part of the axillary margin of the scapula, and is inserted below the lesser tuberosity of the humerus. Professor Humphry considers this to be the hindmost of the three parts into which subscapularis was divisible.

Subscapularis (·22) is normal in all, with five tendinous intersections in our specimen.

Teres major is (·16) large, normal, and separate from the latissimus dorsi in all, and has a surface insertion in Arctopithecus.

Coracobrachialis (·05) has a tendinous origin and insertion, the latter into the second fourth (upper fourth, or nearly upper third, Professor Macalister) of the humerus.

Biceps is a very remarkable muscle, consisting of humeral (·14) and scapular (·04) portions. The former arises by a flat tendon from the lesser tuberosity of the humerus, and from the ridge below it, also by a slip from the deltoid (biceps coracoidalis of Professor Humphry), and one from the deltoidal crest below that muscle; its long tendon passes between these two parts, lying on the bone (quite separate from the scapular portion and anterior to it), to be inserted by a strong tendon into the tubercle of the radius in all. The deltoidal head is described by Meckel, but no trace of it existed in Professor Macalister's specimen. Scapular biceps arises from the top of the glenoid ligament, and continues tendinous as far as the lower border of the insertion of the deltoid, here it becomes fleshy and is inserted musculo-tendinously into the ulna, on the same level as, but anterior to, brachialis anticus. Very nearly the same arrangement exists in B. tridactylus.

Brachialis anticus (·08) arises from the anterior and inner (outer, Professor Humphry) aspect of the humerus, and is inserted into the ulna beside the gleno-ulnar part of the biceps. In Professor Macalister's specimen the tendon of insertion was double, one radial, slightly connected with the insertion of biceps humeralis, and one ulnar, behind scapular biceps.

Triceps is normal in all; t. longus (·12) with a small origin; t. humeralis (·18) had its two heads imperfectly separated by the musculo-spiral nerve in Arctopithecus.

Dorso-epitrochlearis (·02) takes origin from the triceps, and has the usual insertion.

Anconeus externus (·01) is distinct, normal in all, insertion, upper fifth of ulna in Arctopithecus.

Anconeus internus (·01) (epitrochleo-anconeus) arises from the inner condyle of the humerus, and crosses the ulnar nerve in all, overlying (underlying, Professor Macalister) the flexor carpi ulnaris, and is inserted into the olecranon process.

Pronator teres (·10) arises from the inner condyle of the humerus, and has a double insertion into the lower half of the radius, and the anterior surface of the wrist joint. The latter insertion is not mentioned by Professor Humphry.

Pronator quadratus (·02) extends over the lower one-sixth of the fore-arm (lower one-eighth, Meckel), and is described by Professor Humphry as having a broader attachment to the ulna than to the radius.

Flexor carpi radialis profundus, a small muscle in Arctopithecus, arises from the ulna and runs down at an angle of 40° with the fibres of pronator quadratus, to the deep fascia of the wrist. It was not found either by Professor Macalister or Professor Humphry.

Flexor carpi radialis (·02) takes origin from the inner condyle of the humerus, and is inserted into the base of the first metacarpal and trapezium. The latter insertion is not described by Professor Humphry.

Palmaris longus (·04) arises from the same place as the last, and is inserted into the palmar fascia, pisiform and unciform. Professor Humphry found the insertion into the "process of the scaphoid that descends towards met. I."

Flexor carpi ulnaris (·09) is bicipital, one head from the inner condyle, and one from the whole length of the ulna. The two parts are separated by the ulnar nerve, underlie the anconeus internus, and are inserted into the unciform, annular ligament, and base of third metacarpal. Professor Macalister found the second head from the olecranum alone, and the two parts lay over the anconeus internus, whilst the insertion included the pisiform as well as the parts mentioned above. Professor Humphry describes it as being inserted into the distal part of the pisiform, and the fourth and fifth metacarpals.

Flexor digitorum (·95), an enormous muscle partly divisible into condyloid, radial, and ulnar portions, corresponding to the origins

from those parts, supplies the place of the three ordinary flexors of the hand, and terminates in three very strong tendons passing under the annular ligament, which was also very strong, and inserted into the last phalanges of the three digits, which could be easily extended to a right angle with the palm. In Professor Macalister's specimen the muscle was indivisible, and the digits could not be extended to a right angle with the palm without tearing.

Supinator longus (·41) is in two parts, the longest inserted into the lower half (lower extremity, Professors Macalister and Humphry) of the radius, and by tendon (by a few fibres, Professor Macalister) into the external lateral ligament of the wrist. The shorter portion was inserted into the fascia over the wrist.

Supinator brevis is small, pierced by the posterior interosseous nerve, origin humeral, insertion radial. Professor Humphry describes this muscle as being large in his specimen.

Extensor carpi radialis (·10) is single, arising from the external condyle, and inserted into the second metacarpal. In B. tridactylus there are two tendons of insertion, one to the first, and one to the second metacarpal, evidently representing the longer and shorter radial extensors of the wrist as found in most other animals.

Extensor carpi ulnaris (·04) is a small muscle, taking origin from the outer condyle and olecranon process, and inserted into the base of the third metacarpal. Professor Macalister describes its origin as being humeral only, and Professor Humphry found two muscles, one tendinous in origin, from the outer condyle, and inserted into the back of the distal end of the middle metacarpal, the other arising slightly from the condyle, but chiefly from the ulna is inserted into the base of the outer metacarpal.

Extensor digitorum communis (·04) arises from the external condyle of the humerus, and is inserted into the dorsal aponeurosis of the hand, and by fascia along the backs of the three digits. The outer finger had not this prolongation in Professor Macalister's specimen.

Extensor ossis metacarpi pollicis (·11) takes origin from the second and third fourths (middle, Professor Macalister) of the back of the ulna, and is inserted into the base of the inner metacarpal. Professor Humphry describes it under the name of extensor pollicis primus as extending from the ulna to the trapezium.

Extensor indicis (·05) arises from the lower third of the ulna, and is inserted into the base of the inner metacarpal. Professor Macalister describes it as extending from the lower extremity of the ulna to the base of the first phalanx of the inner digit, and Professor Humphry found the same insertion, but the origin from the middle of the ulna.

Extensor minimi digiti arises from the outer condyle of the humerus, and is inserted into the third metacarpal. It was absent in B. tridactylus.

Extensor brevis digitorum (·10) arises from the back of the carpal and metacarpal bones, joins extensor digitorum communis, and is inserted along with it.

Abductor primi digiti (absent in Arctopithecus) extends from the scaphoid and annular ligament to the first phalanx of the inner digit (Professor Macalister).

Abductor annularis (·01) is bicipital, one head from the base of the germ of the outer metacarpal, the other from the pisiform.

Adductor annularis extends from the outer side of the carpus obliquely inwards to the distal end of the fourth metacarpal.

Adductor pollicis arises from the ulnar side of the base of the combined metacarpal, and is inserted into the base of the rudimentary thumb. The first and second palmar interossei, normal in our specimen, and in Professor Humphry's, were absent in Professor Macalister's.

The abdominal muscles are:—

Rectus abdominis takes origin from middle line of the pubis, displays two very oblique inscriptions going downwards, and is inserted into the cartilages of the third, fourth, fifth, sixth, and seventh ribs.

Obliquus abdominis externus arises from the sixth to the fourteenth rib, and is inserted as usual.

Obliquus abdominis internus has its origin from the iliac crest, Poupart's ligament, lumbar fascia, and last rib, its fibres thin above and thick below, run upwards and inwards to the usual insertion.

Transversus abdominis arises from the anterior borders of the costal cartilages and lumbar fascia, is thick above and thin below, and has the normal insertion.

In the hind limb:—

Gluteus maximus (·12) arises from the tuber ischii and sacrum, and is inserted into the upper half of the femur on its outer side. Professor Macalister found its origin from the posterior border of the ilium, and from the side of the sacrum (to which Professor Humphry adds the spines of the caudal vertebræ), and its insertion into the outer part of the femur just beneath the great trochanter, and into the fascia (Professor Humphry).

Gluteus medius (·20) normal, with a little care separable from gluteus minimus (·05) which was also normal. They were found fused by Professors Macalister, Humphrey, and Meckel.

Tensor vaginæ femoris (·05) arises from the anterior superior spine of the ilium (anterior fifth of iliac crest, Professor Macalister), and is inserted into the outer side of the femur below the great trochanter.

Pyriformis (·02) separable without much trouble from gluteus medius, arises from the marginal and anterior surface of the sacrum, and from the posterior inferior spine of the ilium; (the two latter origins were not found by Professor Macalister); the insertion is normal. Professor Humphry found it fused with gluteus medius to "form a large muscle arising from the outer surface of the ilium, from the margin of the sacrum, and from the transverse processes of the

two foremost caudals, and inserted into the outer and anterior part of the great trochanter." Gluteus medius and pyriformis are represented as distinct by Cuvier.

Obturator internus (·04) is moderate in Arctopithecus, small in B. tridactylus (Professor Macalister), if present at all fused with gemelli and quadratus femoris (Professor Humphry). It is displaced on account of the position of the lesser sciatic notch, and is really a gemellus arising from the descending ramus of the pubis.

Obturator externus (·15) is double, one part from the horizontal rim of the pubis, above the obturator vessels, the other as usual from the obturator membrane; the insertion is femoral as usual. It was single and normal in B. tridactylus.

Gemelli both present, and equal in size, united to form a single muscle in Professor Humphry's specimen.

Quadratus femoris (·04) normal, and well developed (Arctopithecus), small (Professor Macalister), if present at all united with the gemelli (Professor Humphry).

Quadratus lumborum in Arctopithecus arises from the sides of the bodies of the three upper lumbar vertebræ, and is inserted into the transverse processes of the three posterior ones, and into the iliac crest. It is not described in B. tridactylus.

Iliopsoas (·33) has the usual origin, and is inserted into the lesser trochanter, and about one inch of the femur below that process. Psoas magnus and iliacus seem to have been distinct in Professor Humphry's specimen.

Psoas parvus (·07) feeble in all, takes origin from the bodies of the two upper lumbar vertebræ, and has the usual insertion.

Levator caudæ takes origin external to longissimus dorsi from the widely expanded transverse processes of the sacral vertebræ, and is inserted into the laminæ of the caudals, one tendon going to each.

Sartorius (·10) arises partly from the anterior superior spine of the ilium, but chiefly from the outer portion of Poupart's ligament, and has a double insertion, one tibial as usual, the other into the inner condyle of the femur and capsule of the knee joint. Professor Macalister only found the former insertion, and Professor Humphry describes the fibres of this muscle at its origin (iliac spine) as being apparently somewhat continuous with those of the external oblique and its insertion to be into the lower internal aspect of the femur, as well as into the upper part of the tibia.

Pectineus (·08) has the usual pectineal origin, and is inserted into the lower half of the femur. Professor Macalister found this muscle to consist of two parts, "arising from the pectineal ridge on the os innominatum, and inserted into the femur for the entire length; the long superficial portion passes internal and nearly parallel to the sartorius, while the deeper part seems to be the true pectineus."

Gracilis (·26) is an enormous muscle arising from the horizontal ramus of the pubis for a distance of half an inch external to the symphysis, and extending outwards from this over the acetabulum to

be inserted into the inner side of the tibia along a line going from below the sartorius to the inner malleolus, also into the fascia of the back of the middle of the leg, and extending outwards to the fascia of the outside of the leg overlapping the biceps. The origin was much the same in B. tridactylus, but Professor Macalister found the insertion only into the inner condyle of the tibia, and Professor Humphry describes it as dividing into two parts, of which the more external has the usual tibial insertion, whilst the other crosses over the back of the leg, and is inserted into the outer side of the fibula, and into the fascia adjacent to it in connexion with the ischial part of the biceps.

Biceps femoris (·21) consists in all of two parts, ischial and femoral, the former of which has the usual origin from the tuber ischii, and also from its ascending ramus, and from the descending ramus of the pubis; the femoral part in our specimen arises from three-fifths of the outside of the back of the femur, and is inserted into the lower two-thirds of the outside of the fascia of the leg. In B. tridactylus the second portion arises from the upper half of the back of the femur on its outer side, and is inserted together with the ischial portion into the head of the fibula (Professor Macalister), into the back of the fibula, and expanding on the back of the leg as far as the heel, uniting with the gracilis (Professor Humphry).

Semitendinosus (·17) and semimembranosus (·14) arise by a common fleshy origin (tendon, Professor Macalister) from the tuber ischii, and are fused for a short distance, then becoming distinct from one another, they run down to their usual tibial insertion. Professor Humphry found them separate from one another for the whole distance, but otherwise as above described.

Adductor longus (·07) arises musculo-tendinously from the horizontal ramus of the pubis under gracilis, and is inserted into the inner femoral condyle. Professor Humphry found a double insertion, separated by the femoral vessels, the anterior narrow one going above the inner condyle, and the posterior broader portion being inserted into the hinder and outer aspect of the lower part of the femur.

Adductor brevis (·07) arises from the anterior border of the tuber ischii and is inserted into the middle third of the linea aspera.

Adductor primus (·14) takes origin from the posterior border of the tuber ischii under semimembranosus, and passes forwards and inwards to be inserted into the lowest part of the internal condyle.

Rectus femoris (·13) has a single head, the usual insertion, and was not surrounded by vastus (·30) which was single and normal. Quadriceps extensor cruris was normal in B. tridactylus. There were three ligaments in the hip joint in Arctopithecus, as in Professor Macalister's specimen, viz.:—capsular, ilio-femoral, and cotyloid, the latter being very faint, and pubio-femoral in direction; as usual there was no ligamentum teres.

Extensor digitorum longus (·14) arises from the heads of the tibia and fibula, as well as from the lower extremity of the femur, its

synovial fold being continuous with the mucous ligament of the knee joint; it is inserted by a weak tendon into the second metatarsal, and dorsal aponeurosis. In Professor Humphry's specimen the origin was from the external condyle of the femur, and the tendon of insertion was strong.

Tibialis anticus (·20) has three heads in all, one from the upper two-thirds of the front of the tibia, one from the middle third of the fibula, and a third from the lower half of the same bone, the latter being larger than the tibial head, as Meckel describes. The same arrangement exactly obtained in Professor Humphry's specimen, whilst Professor Macalister says that the fibular head from the middle third is very diminutive, and describes the second fibular head as extensor hallucis proprius. The insertion of the first and second heads is by a single tendon into the base of the inner metatarsal and entocuneiform (Professor Humphry); the third head has a distinct tendon inserted into the first phalanx of the first digit (entocuneiform and base of Met. I, Professor Humphry).

Extensor hallucis (·09) is a small oblique muscle arising from the lower fourth of the front of the fibula underneath peroneus tertius, and inserted into the first phalanx of the first digit. In Professor Humphry's specimen the insertion was threefold, two tendons going to the last phalanges of digits one and two, and a third to the proximal phalanx of the first digit.

Extensor brevis digitorum arises from the lower extremity of the fibula and from the dorsal aspects of the tarsals and metatarsals; its tendon dividing into three parts joins the dorsal interossei, and is inserted into the three digits. Professor Macalister found the origin tibio-fibular, and the insertion single into the first phalanx of the inner digit, whilst Professor Humphry describes the origin as being only from the tarsals and metatarsals.

Peroneus longus (·14) arises from the external condyle of the femur, and from the upper two-thirds of the fibula, passes downwards in front of the external malleolus, and is inserted into the outer metatarsal.

Peroneus brevis (·02) arises from the lower half (lower two-thirds, Professor Macalister) of the external aspect of the fibula, and is inserted into the outer metatarsal.

Peroneus tertius (·01) is as usual, running from the front of the fibula to the same bone as the two preceding muscles.

Peroneo-metatarsalis in Arctopithecus takes origin from the outer malleolus, and is inserted into the spur-like process of the outer metatarsal, possibly representing a separate part of the last muscle.

Peroneus quartus and peroneo-calcaneus are both absent.

The femur and tibia are articulated in such a manner that they can be brought into one right line, and the knee joint has very strong external and internal lateral ligaments, the latter extending down as far as the upper point of trisection of the tibia; the other ligaments presented nothing of interest. The interosseus membrane between

the tibia and fibula is attached very far forwards, so that the muscles of the back of the leg occupy the inner aspects of both bones.

Gastrocnemius (externus ·09; internus ·11) arises by two heads, one from each condyle of the femur; they are perfectly separate for their entire muscular part (which is longer in externus than in internus); the insertion is by a single tendon into the calcaneum. The action of the whole of this muscle is to invert the sole of the foot.

Soleus (·08) arises from the middle third (upper fourth, Professor Macalister; upper two-thirds, Professor Humphry) of the back of the fibula, with a tendinous slip extending to the head of that bone (Arctopithecus), and has a fleshy insertion into the inner side of the back of the calcaneum underneath gastrocnemius. There are no fabellæ in the origins of either this or the last muscle.

Popliteus (·08) takes origin from the external condyle of the femur, and is inserted into the upper third of the back of the tibia. There is a large wedge-shaped fabella in the origin of this muscle, the tibial surface of which is the larger, and articulates both with the femur and tibia.

Plantaris (·24) large and elongated, arises above the head of gastrocnemius externus, and is inserted into that part of the tendon of flexor digitorum longus, which supplies the middle and outer digits. Professor Humphry did not find this muscle distinct in the animal he dissected, but considers the femoral origin of flexor digitorum to represent it.

Flexor digitorum longus (slip to inner toe ·16; to middle ·11; to outer ·25) is an enormous muscle, with the parts which supply the tendons to the inner and middle toes arising from the posterior aspect of the tibia, and that for the outer toe by two heads, one small from the middle of the tibia, and one large from the upper four-fifths of the fibula and from the strong external lateral ligament of the knee; it receives the plantaris tendon as above described, and is inserted as usual. The bicipital tibio-fibular origin is not described by Professor Macalister, whilst Professor Humphry found it arising in three parts, one from the external condyle of the femur (plantaris), another (the smallest) from the tibia, and a third from the back of the fibula; these supply respectively the tendons to the middle, inner, and outer digits.

Flexor hallucis longus arises from the fibula and interosseus membrane, and uniting with the last muscle is inserted into all three digits.

Tibialis posticus (·04) arises from the lower half of the back of the tibia (and from the head of the fibula in Arctopithecus), and is inserted into the entocuneiform.

Flexor brevis is described by Professor Humphry as a small muscle arising from the calcaneum, and inserted into the sheath of flexor digitorum. We could not find it in our specimen, but it may have been removed in skinning.

Accessorius (inner slip ·05; middle ·03; outer point, ·12;) double, one part arising from the outer surface of the os calcis, is inserted into

that part of the tendon of flexor digitorum longus which goes to the third digit, the other portion from the inner aspect of the same bone is inserted along with the tendons to the other two digits. Professor Humphry describes accessorius as being single, large, taking origin from the anterior and outer surface of the calcaneum, and inserted into the three digit tendons.

In the ankle joint the motion is one of extension and rotation inwards, and flexion and rotation outwards; the anterior ligament is weak and membranous, the internal lateral is very strong, going downwards and backwards to the astragalus and calcaneum, the external lateral is broad. The astragalus is capable of lateral rotation on the calcaneum, has an anterior metatarso-astragular, and a posterior calcaneo-astragular, but no lateral, stays.

The muscles of the digits are, abductor and adductor indicis and medii, all more or less fused; abductor annularis from the rudimentary fifth metatarsal to the extensor tendon of the outer digit; adductor annularis from the fourth metatarsal to the same digit. The two plantar interossei send in two slips on the plantar aspect of the foot.

XLVII.—ON SOME FORMS OF SELENIUM, AND ON THE INFLUENCE OF LIGHT ON THE ELECTRICAL CONDUCTIVITY OF THIS ELEMENT. By HARRY N. DRAPER, F. C. S., and RICHARD J. MOSS, F. C. S.

[Read November, 10, 1873.]

IN a paper read before the Society of Telegraph Engineers* on February 12th, 1873, Mr. Willoughby Smith announced the remarkable fact, that a bar of crystalline selenium, through which a current of electricity passes, has its conductivity increased 15 to 100 per cent. when the bar is exposed to light. The light from an ordinary gas burner placed at a distance of several feet increased the conductivity 15 to 20 per cent. Mr. Smith satisfied himself that alterations in temperature in no way affected this result, by placing the selenium in water, in such a manner that the light from burning magnesium ribbon held some inches above the bar passed through about an inch of water before falling upon the selenium. Under these circumstances, the conductivity of the bar was found to increase more than two-thirds, returning to the normal conductivity when the light was withdrawn.

Lieutenant Sale, in a communication made to the Royal Society,† describes a series of experiments undertaken with the object of ascer-

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* Nature, vol. vii., p. 203.
† Proceedings of the Royal Society of London, volume xxi. p. 283.

taining the relative effect upon the electric resistance of selenium of the light in different parts of the spectrum. He found that in the solar spectrum the conductivity is least in the violet, and increases as the red is approached, attaining its maximum in a position just on the outside edge of the red rays at the red side. The conductivity in this position is greater than in diffuse daylight, but very considerably less than when the selenium is exposed to full sunlight. Mr. Sale observed that the effect of light is apparently instantaneous, but that the return in darkness to the normal resistance is not so rapid. He corroborates the statement of Mr. Willoughby Smith, already cited, that the varying resistance is in no way due to alteration of temperature of the selenium.*

Soon after the publication of Mr. Smith's observations, we undertook a series of experiments with the object of, if possible, determining the precise molecular state of selenium, which exhibited this phenomenon of diminished electrical resistance under the action of light, and the conditions necessary for its production.

It would here appear necessary to give a brief *resumé* of the state of our knowledge of the physical properties and relations of selenium. This is of the more importance because little, if anything, has been added to that knowledge for nearly twenty years, and because the statements in some of the acknowledged text-books are not only insufficient, but often discordant with the results obtained by the *savants* to whom we owe all that up to this time has been done in relation to the subject.

As we would desire to avoid matter which is supplied by handbooks of chemistry, or details not directly bearing upon our investigation, it must be understood that we note here only those hitherto observed and not widely known characters of selenium which seem to us to be in intimate relation to the phenomena we have made the objects of experiment.

Selenium, discovered by Berzelius in 1817, was carefully studied by that chemist, and it is through his researches, and those of Regnault, Mitscherlich, and Hittorf, that we have almost all our knowledge of the physical characters of this element. It is upon their authority that the following statements are made.

Selenium may exist in several different forms :—

1°. As a vitreous mass, with conchoidal fracture.

2°. As a red amorphous powder precipitated from selenious acid or selenites by the action of reducing agents.

3°. In the form of minute crystals deposited from its solution in bisulphide of carbon.

4°. In crystals deposited from solutions of the alkaline selenides exposed to the air.

5°. As a granular body resembling, almost completely, metallic cobalt or cast iron, and obtained by the heating and slow cooling of either of the three first-mentioned forms.

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* No experiments are adduced in support of this statement.

The first three modifications it should be mentioned, resemble one another in their physical and chemical relations, and must be regarded as different conditions of the same allotropic form of selenium.

It is here only necessary to speak of vitreous selenium, and of its heat-produced allotropic modification, the granular variety, or as it has been felicitously called by Regnault, metallic selenium.

Vitreous selenium has no definite point of fusion. At temperatures exceeding 60° C. it softens, becoming gradually softer with increased heat, and being perfectly fluid at 250°. When rapidly cooled from this temperature, it returns to its original condition. At normal temperatures it may be kept without change of state for many years, and is probably under these conditions perfectly stable. It is, though very sparingly, soluble in bisulphide of carbon. In thin films, it appears by transmitted light of a beautiful ruby-red colour. Its specific gravity is, according to Schaffgottsch, 4,276.

When this vitreous selenium is maintained for some time at any temperature between 94° and 200° C., and is then slowly cooled, it is found to have assumed a metallic appearance, and to have a grey granular fracture. It is now, we ourselves find, perfectly opaque to light, even in the thinnest films. Its specific gravity has increased to 4·796. When heated it does not soften, but at 217° fuses without taking any intermediate pasty condition. At 250° it is perfectly fluid, even when the mass is considerable; and when rapidly cooled returns, without any tendency to crystallize, to the vitreous, non-metallic modification. All that has up to the present been made known as to the electrical relations of selenium may be very shortly told.

Solid vitreous selenium cannot, according to Berzelius,* be rendered electrical by friction, but on the contrary Bonsdorff† states that when rubbed in very dry air it has this property.‡ Knox found that fused selenium conducted the current of a battery of sixty pairs. Hittorf § found that granular selenium at normal temperatures conducted sufficient of the current of one Grove's element to deflect the astatic needle of a galvanometer having 200 convolutions 17°, and that when the selenium was heated to 210° in a small crucible the needle marked 80°. But when the temperature reached 217° (the point of fusion of granular selenium), the needle went back suddenly to 20°.

The action of light as probably effecting some change in the allotropy of selenium was not wholly unsuspected prior to Mr. Smith's observations. Gmelin mentions exposure to sunlight as a favourable condition for the precipitation of selenium from dilute solutions of

* Gmelin—Handbook, ii., p. 236.

† Gmelin l. c.

‡ Gmelin l. c.

§ Poggendorf Annalen der Physik und Chemic, Bd. lxxxiv, p. 214.

selenious acid by sulphurous acid; and Hittorf, while noting the likelihood of such an influence, was unable to detect it, and was obliged to attribute the observed change of amorphous into crystalline selenium, while drying in sunlight, entirely to the effect of heat. In pursuing the line of research we have marked out for ourselves, we have been obliged to repeat much already published work, which with improved means of experiment has lost somewhat of its significance. We have thus encountered several apparently contradictory statements, some of which our experience has either failed to verify, or has placed in a new light; and we have been convinced that the properties of this remarkable substance are but imperfectly understood, and still present a wide field for investigation. Vitreous selenium is, we should say at the outset, apparently an absolute non-conductor of electricity. We have been unable to obtain any deflection of the very sensitive astatic needle of a high resistance galvanometer, when the thinnest films of selenium, of the continuity of which we could assure ourselves, are interposed in the circuit of ten Leclanché elements. The difficulty of producing very thin films of absolute continuity disposes us nevertheless to state our belief, as to the complete non-conductivity of vitreous selenium with some reservation.

As might be expected from this character, selenium in the vitreous form becomes electric by friction. So easily indeed have we invariably obtained this result that we find it difficult to understand the contrary conclusion of Berzelius.

Hittorf, as has been stated, found that when vitreous selenium is converted into the granular form its electrical resistance diminishes directly with its temperature, but that when 217° is attained the resistance is suddenly and largely augmented. In repeating this experiment we have obtained results concordant with those of Hittorf, who appears, however, not to have exceeded the temperature of 217°. Going beyond this point, we find that the resistance diminishes up to the point of complete fusion of the selenium, being at its maximum at 250°. We have obtained also the remarkable result that when the vitreous selenium resulting from the rapid cooling of the completely fused granular form is quickly heated, it begins to conduct the current at a temperature between 165° and 175°, and that its resistance diminishes, not only up to the extreme range of the mercurial thermometer, but so much beyond that it is still diminishing when, owing to the rapid volatilization of the selenium, it has been found necessary to terminate the experiment.

It has hitherto been assumed that there is but one granular form of selenium, and that this is a conductor of electricity. We have, however, obtained a granular form in no way optically differing from granular selenium of comparatively low resistance, through a rod of which, 16m.m. long and 3m.m. diameter, the current of ten Leclanché cells does not in the least deflect the needle of our highly sensitive galvanometer. Nor does light, so far as our experiments have yet gone, diminish the resistance of this modification. We have on the other

hand succeeded in obtaining bars of granular selenium through which the current of one Leclanché cell causes a very considerable deflection of the needle. This form is, we find, in its electric resistance almost unaffected by light. Between these two forms of granular selenium—the apparently non-conducting and the comparatively highly conducting—there is another of intermediate resistance. This modification is highly sensitive to light; its conductivity when in the form of flat bars increasing in direct sunlight 75 to 100 per cent., and in artificial light in ratios ranging from 10 to 50 per cent.

One form of granular selenium, as Hittorf first showed, has its resistance considerably diminished by heat: indeed, he says that could it be heated red hot its conductivity would not be inferior to that of the metals. Our own experiments confirm the diminution of conductivity by heat, but we have found, in at least one modification which we have produced, a body which so far conforms to the metallic type as to have its resistance strikingly increased by heat. We have made bars of selenium which when placed in the circuit of a battery and galvanometer, have shown a deflection of 48°, while upon completing the circuit of a nitric acid battery, the current of which heated a spiral of patinum wire surrounding the bar of selenium, the needle gradually fell to 15°, as the temperature of the bar became greater.

For the present we refrain from comment upon these results; and although we have been engaged during many months in this investigation, we defer details of our experiments, and especially of the conditions under which the different electrically resisting and light-sensitive forms of selenium are obtained, until with larger experience we may hope to bring before the Academy results tending more closely to the solution of the questions we have proposed to ourselves.

XLVIII.—ON A SUPPOSED SUBSTITUTION OF ZINC FOR MAGNESIUM IN MINERALS. By EDWARD T. HARDMAN, F. C. S., &c. (of the Geological Survey of Ireland.)

[Read January 26, 1874.]

THE investigation undertaken by me—viz., An Inquiry into the Effect of the Contact of Igneous Dykes and Masses with other Rock Masses, and the true nature of the Alteration so often observed under such circumstances—has been necessarily a tedious one, and one which will require a careful analysis and comparison of very many rock-specimens ere a conclusion of any value can be arrived at on the subject. I shall therefore reserve, for the present, the account of my work on the original matter of inquiry.

In the course of my research, however, a discovery of much interest and some importance was made; and I wish, therefore, in this Report

to lay it before the Royal Irish Academy, so far as it has yet been pursued.

It refers to the occurrence of zinc in magnesian minerals, and in rocks containing magnesian compounds.

1. *Chalk.*—During an analysis of the white limestone (chalk) of the county Tyrone, I chanced to notice the presence of zinc in small quantity, although on inspection even with a lens, no trace of any zinc mineral could be discovered, and as I could find no analysis of limestone or other rock in which this metal was given, I thought it worth while to notice it at the time.* The first specimen examined was from Legmurn, near Stewartstown, county Tyrone. Another was then procured from an isolated patch of chalk on the top of Slieve Gallion carn, county Derry, about eight miles distant from the first. Zinc was also found in this. In both cases it was distinctly reduced by the blowpipe from the powdered rock mixed with carbonate of soda; but in the first specimen its presence was confirmed by a complete wet analysis of a large quantity of the chalk—viz., 297·5 grains, the amount being, however, too small to estimate.

2. *Basalt.*—It then occurred to me to examine the overlying basalt: and a specimen No. 1, was obtained from a place about 300 yards northeast of the chalk quarry in Legmurn. Four or five grains at a time, treated with carbonate of soda on charcoal, before Fletcher's hot-blast gas blowpipe, yielded enough of the metal to identify, and the characteristic zinc reactions were distinct.†

I was under the impression at the time that the zinc, possibly occurring in the chalk as a carbonate, had been brought down from the overlying basalt by the infiltration of water; having been originally introduced into the latter rock by the same means, alike with the calcareous minerals and zeolites filling up the vesicular cavities in it: but this I now believe to have been not altogether the correct solution; and subsequent examination and consideration have led me to what seems to be the true clue.

At the time that the paper containing the account of these analyses was read, exception was taken to that part of it which related to the existence of zinc in the basalt, on the ground that the metal in question had never been known to occur in rocks of igneous origin; but as I had every reason to believe my analyses were perfectly trustworthy, I saw no cause to modify my statement on the objection then put forward. Since then, whilst examining—with a different investigation in view—a piece of basalt from another locality in the neighbourhood of that from whence the first was procured, I succeeded in again find-

* On the Analysis of White Chalk, &c., with notes on the occurrence of Zinc therein. Journal of the Royal Geological Society of Ireland, vol. iii., pt. 3, p. 159. Also Geological Magazine, vol. x., No. 10, p. 434.

† *Supra cit.*

ing zinc in *it*, thus confirming my former analysis. It may be well to give the details of the examination.

Basalt, No. 2.—The specimen was taken from the heart of a quarry by the road-side, in Curglasson, being more than a mile north of the spot where the basalt No. 1 came from. The rock was carefully examined in the wet way for the heavy metals, &c., precipitable from an acid solution by sulphuretted hydrogen. Iron and alumina were precipitated, and the filtrate then examined, much pains being taken to guard against error. On the addition of ammonium sulphide, a distinct white precipitate appeared. As it was possible that a little lime was also brought down, the precipitate was filtered off, redissolved in hydrochloric acid, and reprecipitated. (*a*) It was again dissolved, the solution evaporated to dryness, and ignited to drive off ammoniacal salts. A small portion of the residue—*which was deliquescent*—mixed with carbonate of soda, and exposed before the blowpipe on charcoal, gave the usual zinc oxide incrustation, which, treated with nitrate of cobalt, gave a vivid green. The fused bead and support, being levigated with water in an agate mortar, gave numerous spangles of white metal; and these, when treated with a drop of water slightly acidulated with hydrochloric acid, dissolved quickly with evolution of hydrogen. As the solution (*a*) could only contain zinc, with a trace of ferrous iron, and lime, this experiment was conclusive.

The above results were obtained with portions of the rock treated in the following different ways.

(1) The powdered rock was fused with carbonate of soda.
(2) „ „ boiled in strong hydrochloric acid.
(3) „ „ boiled in nitro-hydrochloric acid.

It is somewhat remarkable that only a trace of titanium was observed in this specimen.

But, previous to making this analysis, I had come to the conclusion that there was good reason to suspect the frequent occurrence of zinc in igneous as well as aqueous rocks, on the following considerations.*

Zinc is very closely allied to magnesium in characteristics and behaviour. In many points the resemblance is very strong,† in the metallic state as well as in combination with other elements. The salts of both have a similar composition; and they, as well as the respective natural compounds, or minerals, are isomorphous.‡ Consequently, following the law of isomorphism, the metals should be mutually replaceable, and wherever the one is found in any quantity, we should expect to find the other encroaching upon it,—judging by analogy of what

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* I have already pointed out that zinc minerals have been known to exist in igneous and metamorphic rocks. See paper already cited.

† Fownes' Manual of Chemistry, 10th edition, pp. 293 and 393. Also, Galloway's Qualitative Analysis, 5th ed., p. 49.

‡ *Supra cit.* Also, Dana's Manual of Mineralogy, p. 74.

takes place in other minerals. It is curious that while in most mineralogical treatises the interchangeability of the protoxides of iron, manganese, calcium, and magnesium is pointed out, that of zinc with these —so far as I am aware—has not been yet shown; and in the very few instances in which it is given as an accessory metal, its presence appears to be considered rather as an accidental circumstance than as the result of any chemical law. In no case has it been given in the composition of a mineral, unless present in such quantity as to make a very serious item in the analyses, as in those of Automolite, or zinc spinel (20 to 35 per cent. ZnO) and Franklinite (17 per cent. ZnO).* Yet with regard to most minerals, traces of manganese, iron, magnesium, &c., are constantly recorded as replacing part of the essential metals.

Believing, therefore, that zinc compounds might thus be expected to exist in most magnesian rocks or minerals, I have examined several, and, so far, the result has almost exceeded my anticipations, for in every case the metal has been proved. As yet I have merely satisfied myself as to its presence, reserving quantitative determination until I shall have completed the qualitative examination of a number of specimens; but it may be well to mention the rocks and minerals already tried.

1. *Chalk*, from Legmurn and Slieve Gallion; already described.

2. *Basalt* No. 1.

3. *Granite*,† Wicklow and Wexford Range variety, from Graiguena-Spiddoge, near Carlow: obtained from the heart of the quarry.

(*a*) A very coarse-grained, light-coloured rock, porphyritic in parts, containing white mica and a dark greenish magnesian variety; also tourmaline. The portion submitted to analysis was prepared in such a way as to have as much mica as possible present. Four analyses of this were made in the wet way, as well as others with the blowpipe, ere I allowed myself to be perfectly satisfied as to the presence of zinc. The quantity was very small, as was, of course, to be expected. Traces of copper and lead were also observed.

(*b*) *Mica.*—After many searches at the same quarry, I was able to obtain a mass of mica sufficiently large for analysis with the blowpipe;‡ it was mostly white mica, but contained numerous laminæ of green mica.

About four grains at a time were treated with carbonate of soda, on charcoal, before the blowpipe. Two metals were reduced, which proved to be copper and zinc. The zinc spangles dissolved with rapid evolu-

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* Is it not possible that Franklinite is a Magnetite with the ferrous iron replaced by zinc? Spinel is a magnesian mineral, and its accessory metals belong to the same isomorphous group.

† Automolite has been found in granite, at Haddam. Dana's Manual of Mineralogy, p. 161.

‡ In all cases the blowpipe gave very distinct results, even where a large quantity of material was required for decided reaction in the wet analyses.

tion of hydrogen in a barely acid solution of hydrochloric acid; the solution evaporated, moistened with nitrate of cobalt, and heated before the blowpipe, gave the characteristic green reaction.

4. *Serpentine* (?).—A green, soft, steatitic rock, from Garrarus strand, near Tramore, Co. Waterford. This rock occurs among silurian limestones and slates, near masses and dykes of felstone, &c. Some of the limestone can be seen to pass into serpentine.

Examined qualitatively for zinc: found it present in fair quantity. The rock contains about eight per cent. of water, and eleven per cent. of carbonic acid,* being evidently a passage rock.

5. *Basalt*, No. 2, from Curglasson; already described.

6. *Black Mica*, in a gneissose or granitic rock. Locality unknown. Specimen from Geological Survey collection.† The mica is perfectly black, and occurs in quantity, in small flakes thickly massed together.

About four grains were treated at a time, before the blowpipe, with carbonate of soda. After fusion, the mass yielded a notable quantity of copper, a very appreciable amount of zinc, and a trace of a metal supposed to be lead. All the characteristic tests for zinc were answered very distinctly.

7. *Chlorite Schist* (? Talc Schist), from Geological Survey collection, with enclosed grains of glauconite.—The examination with the blowpipe gave two metals, copper and zinc, both in very appreciable quantity. The zinc reactions were very pronounced.

8. "*Mountain Leather*," variety of asbestos; from Portlock's collection, Geological Survey Museum. Locality unknown, but associated with basaltic minerals from Antrim. Zinc very apparent, all the reactions being most distinct. A trace of lead also observed.

9. *Augite*.‡—Very large crystals in a trappean ash. Locality unknown. Geological Survey collection. About four or five grains of the powdered mineral, fused with carbonate of soda on charcoal, yielded a sufficiency of metal to identify with certainty. Besides zinc, copper was present. The zinc reactions were most distinct.

These rocks and minerals are not selected from a number containing specimens in which no zinc was found, but comprise all that I have as yet examined for it. They were for the most part chosen on account of containing, or being themselves, magnesian compounds; and they are numbered in the order in which they were tested, none proving blank. In many cases the examination by the blowpipe and its immediately-connected wet tests were found to be amply sufficient to prove

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* Carbonic anhydride, CO_2.

† The specimens from the Geological Survey Museum were obtained by the kind permission of Prof. E. Hull, F.R.S., Director of the Geological Survey of Ireland.

‡ Zinc is recorded as occurring in Augite in one instance; Jeffersonite; a lime-iron; Manganese; Zinc pyroxene; in Dana's Manual of Mineralogy (1854). As only the same specimen is given in the new edition (1874), I conclude that no account of any other has been published. The analysis itself was published in 1822. [*Added in Press.*]

the presence of the metal, especially as, from the comparatively large amount of the substance taken—four or five grains*—there was little possibility of error. Where, however, the result seemed to be at all doubtful, it was confirmed by one or more analyses in the wet way.

The zinc appeared to be always most plentiful where there was the largest quantity of magnesium; but, as I am at present only concerned in proving the *existence* of the former metal in the above minerals, I am not just now in a position to positively assert this, deferring any quantitative estimation until I have continued the investigation so far as to enable me to select the best typical examples. In the meantime these notes on the subject may not be without some interest, bearing as they do on a matter of much importance, from a mineralogical as well as a chemical standpoint.

It may be thought that the zinc might as well be considered to replace the other members of the isomorphous group, which are known to occur in traces, and occasionally in quantity, in some of these minerals. But this would be a replacement of a replacing element, and I believe it is invariably considered that the accessory mineral substitutes itself for part of the essential metal. On this ground alone, all the minerals here referred to being strictly magnesian, the zinc must be regarded as replacing magnesium. At the same time I do not doubt that in cases where there is no magnesium, it may be equally found to replace the other metals.† But when we remember the affinities of the two metals, it will hardly be thought a far-fetched notion to suppose that, were a preference possible, the zinc would associate itself with the magnesium, in the same way as some other metals are found in nature; notably those of the platinum group, which, possessing a very peculiar relation to one another independently of their isomorphism—which is not thorough—are nearly always found together.

It will be seen that the majority of the minerals examined are species that are most often found in nature forming component parts of igneous rocks, while two rocks of that class are themselves included.

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* This was rendered possible, in some cases, by the use of paraffin oil for the blowpipe lamp. By this means a very large and hot flame was procured, capable of decomposing a much larger quantity of rock. For reductions, and when great heat was required in blowpipe analyses, it proved very useful, where gas was unattainable.

† Since this paper was read I have found it replacing Iron in Iron-pyrites. [*Added in Press.*]

XLIX.—ON THE ANATOMY OF AONYX. By ALEXANDER MACALISTER, M. B., Professor of Comparative Anatomy and Zoology in the University of Dublin.

[Read November 10, 1873.]

IN the valuable collection of animals collected by the late lamented Viceroy of India, the Right Hon. the Earl of Mayo, for the Dublin Zoological Gardens, was a fine specimen of the laughing otter of the Indus. This animal lived for a few months in the gardens, but in the month of August last it suddenly sickened and died, and was purchased for the Museum of the Dublin University by Professor Haughton. On examination, its conical tapering, hairclad tail, its bald soles, muzzle edge and columella, its oblong feet with slender free-tipped toes and imperfect claws, its large pad, and separate toe-pads; its broad, dedepressed skull, showed that it was a member of the genus Aonyx established by Lesson. The index and middle toes show a tendency to unite to the third joint, the inner toe is short, the fifth shorter than the index; the skull is rather short, convex behind; the flesh tooth has a large internal lobe nearly as long as the outer portion of the tooth, with two cross ridges on the crown; the upper tubercular grinder is large, massive, rather wide than long.

The Asiatic species of the genus Aonyx are three in number. A. leptonyx of the Indian Archipelago, which has pale brown cheeks, chest, and sides of the neck, white chin and upper part of the throat, and brown back; A. indigitata, which has very short toes and blunt rudimental claws; and A. aureobrunnea, the small golden and brown otter of Nepaul. Our specimen agrees with the descriptions of none of these very accurately.

With the assistance of Mr. Mackintosh, I made a very accurate dissection of this animal, and the following are the details thereof. Pending the compilation of a general account of the anatomy of the musteline section of the carnivora, I have confined myself to the description of the species without introducing any comparison.

The panniculus carnosus was strong, and overlay the strong laminar connective tissue of the neck and thorax. The following parts of it were recognised. 1. Platysma myoides from the inferior surface of the thoracic integument to the ramus of the mandible, its fibres running upwards and inwards, and forming a strong superficial stratum in the neck. A second or nuchal panniculus arose along the medial line of the neck from the first dorsal spine to the occiput. The fibres ran forwards and outwards obliquely, overlapping the trapezius to be inserted into the skin and connective tissue of the side of the neck. The occipital segment of the occipito-frontalis is a detached flat band of this muscle. A strong transversalis nuchæ underlay the nuchal platysma, and ran from the middle line directly outwards to the integument

at the back of the ear. The pectoralis quartus, or brachio-lateral panniculus was also very strong, attached to the seven lower ribs, and to the lumbar fascia, and inserted into the axillary tendinous arch stretching from the great pectoral to the latissimus dorsi, with both of which it was, as usual, inseparably united; the abdomino-femoral panniculus also formed a strong radiating sheet, whose anterior margin was sharp and definite, and whose lower insertion extended along the entire thigh.

On raising the panniculus and exposing the endoskeletal muscles, we found the sternomastoid large and distinct, arising from the proosteon by fleshy fibres, and inserted tendinous into the paroccipital and into the ridge leading forwards from it to the paramastoid. The perfectly separate cleidomastoid above was attached to the paroccipital under the last, and below its fibres pass with the upper edge of the superficial part of the great pectoral beneath the anterior edge of the clavicular trapezius; the sterno- is to the cleido-mastoid as ·38 to ·19.

The trapezius was divisible into three parts; trapezius clavicularis, scapularis superior, and scapularis inferior. The first portion arose by an extensive fleshy expansion from the occipital crest beneath the nuchal platysma, and crossed by the transversus nuchæ, its fibres pass down parallel to the hinder edge of the sterno-mastoid, and overlapping the cleido-mastoid, they end in an imperfect tendinous line, which represents the clavicle; below this line the fibres are continued onwards as the clavicular deltoid. This inscription has in it no floating bone, nor is it perfect, as on the deep surface many bundles of muscular fibres pass directly from the trapezius into the deltoid.

The trapezius scapularis superior arises below the last from the spines of the 2–7 cervical vertebræ, and is inserted into the spine of the scapula along its anterior edge, as far back as the insertion of the trachelo-acromial muscle. The inferior scapular portion arises from the 2–8 dorsal spines, and is inserted into the Retzian tubercle of the lower edge of the scapular spine by a flat tendon.

There is a strong trachelo-acromial, as usual in otters, arising from the outer edge of the transverse process of the atlas, and inserted into the metacromion, at its base; the insertion intervened between the attachments of the clavicular and upper scapular trapezius muscles. Rhomboideus arises from all the cervical and two upper dorsal spines, and was inserted as usual; the occipital portion is distinct at origin from the cervical, and inserted as usual, extending anterior to the upper angle of the scapula.

The latissimus dorsi arises from the 3rd to the 9th dorsal spines, and its tendon of insertion was joined to that of the teres major inseparably. The distinction between this muscle and the pectoralis quartus (*vide supra*), was purely artificial. Taken together, they weighed 0·88 oz. separately they weighed, pectoralis quartus 0·61, latissimus 0·27.

In all otters a second muscle exists intermediate between the levator anguli scapulæ and the trachelo-acromial, which is probably a

dismemberment of the former, arising from the transverse process of the atlas, and inserted into the posterior fourth of the spine of the scapula. Indeed both the trachelo-acromial and this muscle bear the same relation to the levator anguli scapulæ that the levator bears to the serratus magnus, all being fragments of the pleuro-scapular sheet, whose separateness depends on the relative and independent degrees of motion of the different regions. This lutrine muscle we may call trachelo-scapular; it is less than the trachelo-acromial (0·17 : 0·10).

The splenius capitis arises from the 1–3 dorsal, and 2–7 cervical spines, and is inserted below the sterno-mastoid into the par-occipital process and outer part of the occipital crest. Splenius colli is very weak. Serratus posticus superior extends from the upper 9 dorsal spines to the 1–11 ribs. Serratus posticus inferior is attached to the three lower ribs. Trachelo-mastoid passes from the 7th cervical, and 1–2 dorsal transverse processes to be inserted into the par-occipital, and has no tendinous inscriptions. Complexus arises from 3–7 cervical transverse processes, and is attached below the occipital crest. Biventer cervicis arises from the 2nd–4th dorsal transverse processes, and extends to each side of the median line of the occiput, four tendinous inscriptions cross it in its course.

The rectus capitis posticus major consists of two separate superposed laminæ; the other small nuchal muscles were regular; the entire muscular mass for raising and drawing back the occiput was very large, as in all the Mustelidæ, and weighed 3·40 ounces. The iliocostalis consists only of two parts—iliocostalis lumbalis and iliocostalis dorsalis: there was no cervical prolongation. The longissimus dorsi, which had its usual double sets of tendons in the dorsal region, is continued up to the second cervical transverse process. The spinalis dorsi begins tendinously in the middle of the lumbar region, and is inserted by a tendon into each spine as far as the axis. Semispinalis formed a continuous lamella, and overlay in the dorsal region the multifidus spinæ, which had no cervical representatives.

The omohyoids were feeble and went from the basihyal to the fascia over the supraspinatus, along the upper edge of the scapula. Sterno-hyoid and thyroids were with difficulty separated, and were as usual traversed by an inscription.

A strong transverse layer of muscle arose from the zygoma, and from the fascia behind it, passed transversely over the angle of the mandible, and was inserted into the median line. It underlay the rest of the platysma, of which it was a dismemberment, and was separated from the digastric by a thick layer of the cervical fascia.

The digastric is a single thick muscle, traversed by an inscription, and arose from the paramastoid, passes forwards to be attached to the hinder half of the lower border of the mandible. The mylohyoid is strong, thick, and transverse,. The geniohyoidei are united to these, and to the geniohyo-glossi. The stylo-glossi were wide and short, and attached to the ceratohyals. The bilaminar oblique masseter was joined to the temporal, and both weighed 1·14 ounces on each side.

The pectoralis major consisted of two parts, one from the median line of the front wall of the thorax, running transversely to the whole length of the humerus. The middle fibres are common to the two sides, the deeper fibres run transversely. A second perfectly separate part of the great pectoral springs from the whole length of the sternum and is also inserted into the whole length of the humerus. The superficial is to the deeper part as ·5 : ·87.

There was no pectoralis minor nor subclavius. The deltoideus clavicularis arises from the inscription in which the fibres of the trapezius clavicularis ended; some fibres of the latter muscle, however, being directly continued into it without any tendinous intersection. The insertion is into the middle three-fifths of the humerus. The acromial deltoid arises external to the metacromion from the extremity of the acromion proper, and is inserted into the upper part of the deltoidal crest just behind the clavicular part. The scapular deltoid springs from the whole length of the spine of the scapula behind the metacromion, and is inserted underneath the acromial part. These parts are related as follows in size:—Clavicular - 0·18; acromial 0·06; scapular 0·06.

The supraspinatus is to the infraspinatus as 0·35 : 0·2. The teres minor was absent altogether in the right arm, but represented on the left by a slight thread along the inferior margin of the infraspinatus, made of fibrous tissue without the slighest trace of muscle. The teres major was large, nearly equalling the infraspinatus; subscapularis was intersected by five tendinous planes, and had no separate subscapula-humeral slip. The serratus magnus arises from the seven upper ribs and from the six lower cervical transverse processes, by a continuous origin, its insertion is into the hinder part of the meso-and post-scapulæ.

Coracobrachialis was absent in the right arm, present as the short variety in the left.

The biceps is gleno-radial and penniform as usual, with its insertion on a plane lower than that of the brachialis anticus. The brachialis arises externally from the whole length of the humerus, and is inserted into the ulna as usual. They were to each other as follows:—Biceps = 0·13: Brachialis = 0·11. The long head of the triceps arises from the outer half of the axillary border of the scapula, and was quite separate for its whole length, the two laternal heads were also separable. The dorsi-epitrochleais arises from the upper edge of the latissimus dorsi tendon, and from the border of the infra-spinous fascia; it was very large and inserted into the olecranon, and into the inner side of the fascia of the forearm for more than one-half its length. There were two equal anconei, externus and internus. In the arm, the flexors were to the extensors, as 0·24 : 1·36. The pronator radii teres was inserted into the third and fourth-sixths of the radius. The flexor carpi radialis was normal, the flexor ulnaris completely double, consisting of an olecrano-pisiform, and a condylo-pisiform part, which are respectively 0·13 and 0·03 in size; the latter arises in common

with the palmaris longus, which was inserted into the palmar fascia, and sends a fascial slip into the thumb. The flexor digitorum sublimis arises from the front of the flexor digitorum profundus tendons and sent tendons to the second, third, and fourth digits; the flexor profundus and flexor pollicis longus, as usual, had five heads, a radial condyloid, an ulnar condyloid, a mediar condyloid, an ulnar, and a radio-ulnar, the last being the morphological equivalent of the flexor pollicis. From the common mass were detached five tendons, which were distributed as usual; the second, third, and fourth of these had lumbricales attached thereto. The pronator quadratus stretched for half the length of the forearm.

The supinator longus was very remarkable, its origin stretched above the pit for the brachialis anticus on the outside of the head of the humerus; from this unusually high origin its fibres descended to the lower end of the radius and annular ligament, the fibres being continuously fleshy for the whole way down.

There were two radial extensors of the carpus, long and short; the first arose from the ridge above the outer condyle 1¼″ below the origin of the supinator longus, it was inserted by two tendons, one on each side of the metacarpal of the index. The teudon is united by a cross slip to that of the extensor carpi radialis brevis.

Supinator brevis extended to the lower third of the radius. The extensor digitorum longus was inserted by four tendons, of which those to the fourth and fifth digits united with those of the next muscles.

Extensor minimi digiti arose as usual and was inserted into the second phalanx of the little finger; separate from it was an extensor tertii et quarti digiti, which arose from the outer condyle and ended in two tendons which bifurcated and passed to the third and fourth, and to the fourth and fifth digits.

The extensor carpi ulnaris is normal, as is the extensor ossis metacarpi pollicis (inserted into the radial sesamoid and first metacarpal. The extensor pollicis et indicis is purely ulnar in origin, and gives off first, a tendon to the index, then one to pollex and index.

The short muscles of the hand are:—Abductor minimi digiti from the pisiform to the first phalanx, in two slips. Abductor minimi digiti from the fascia over the trapezoid to the first phalanx. Abductor pollicis from the scaphoid to the first phalanx. Opponens pollicis to the metacarpal adductor from the os magnum, and flexor brevis pollicis from the trapezium. There is also a flexor brevis minimi digiti from the unciform. There are three palmar and four dorsal interossei arranged as usual.

The large flat tail had great lateral fat masses and thirteen pairs of strong levatores caudæ.

The sartorius is double at origin, one part arises from the whole length of the iliac crest, the other arose from Poupart's ligament; both joined and formed one band which was inserted into the border of the ligamentum patellæ at its tibial end; the former head was larger than the latter (0·18 : 0·08).

Tensor vaginæ femoris arises from the anterior edge of the iliac crest beneath and outside the sartorius and was inserted into the fascia as usual.

The psoas parvus arises from the two upper lumbars and is inserted behind the pectineus.

Iliopsoas arises from the two lower lumbar vertebræ and by a few fibres from the front of the ilio-lumbar ligaments, but not from the ilium, and is inserted into the lesser trochanter.

Pectineus arises from the strong prominent pectineal tubercle, and is inserted into half of the length of the shaft of the femur. Adductor primus arises from the tuber ischii along with semimembranosus, and is inserted immediately above the inner condyle of the femur. The second adductor is not divisible, and arises from the whole outer surface of the ischiopubis in front of the tuberosity, it is inserted into the whole length of the linea aspera of the femur.

Adductor longus arises internal to the pectineus from the horizontal ramus of the pubis, and is inserted into the anterior surface of the inner condyle of the femur. Quadratus femoris is long and strong. Obturator externus is large. Obturator internus has a large superior and a rudimental inferior gemellus.

Agitator caudæ arises from the fascia over the anterior two or three caudal vertebræ, posterior to the gluteus maximus, from which it is with difficulty separable; it is inserted into the middle third of the femur. Gluteus maximus arising anterior to the last is inserted into the root of the great trochanter above the last. Gluteus medius arises from the whole iliac dorsal fossa; pyriformis is scarcely separable, and is inserted together with the gluteus into the great trochanter, but arises from the interior surface of the sacrum with the pelvis.

Gluteus minimus arises from the anterior border of the iliac fossa, it is $\frac{1}{6}$th the size of the gluteus medius. The gluteus quartus still smaller has a long marginal tendon of origin and is inserted in front of the great trochanter.

Caudofemoralis arises from the transverse process of the first caudal vertebra, and is inserted into the outer popliteal ridge of the femur. Coccygeus runs from the spine of the ischium downwards and backwards as far as the fourth caudal vertebræ.

There is a strong ligamentum teres in the hip joint. In the shoulder joint the spino-glenoid ligament is prolonged outwards to the humerus between the supra and infraspinati muscles. There is also a strong internal gleno-humeral ligament.

Biceps femoris is a large muscle arising from the tuber ischii, and is inserted into the whole length of the fascia outside the leg; under it lies a long strap-like bicipiti accessorius which springs from the first caudal vertebræ under cover of the caudo femoralis, and is inserted into the calcaneum.

Semimembranosus arising from the tuber ischii is inserted into the inner side of the head of the tibia. Semitendinosus arises from two or three caudal vertebræ, together with a fine slip from the tuber

ischii which joins the rest of the muscle beyond the inscription (which is as usual). This is inserted into the inner side of the tibia two-fifths from the top of the tibia.

Gracilis arises from the whole symphysis, and is inserted into the upper third of the tibia. Rectus femoris lies as usual between the vasti. The extensors of the knee are to the flexors as 1·00 : 1·31.

Popliteus extends to the upper two-thirds of the tibia. The two heads of the gastrocnemius are as usual, the external joined to the plantaris, and neither has a fabella. Plantaris arises from the outer condyle and passes over the back of the os calcis, their fleshy fibres become mixed up with the tendinous fibres, and its tendons are inserted into the five toes.

Soleus arises by a thin flat tendon from the head of the fibula; at the lower third of the leg it becomes fleshy, and is inserted into the os calcis.

The flexor digitorum longus and flexor hallucis are fused at their insertion, and send tendons to all the toes.

Tibialis posticus is tibio fibular in origin and scaphoid in insertion. There is a well-marked accessorius which arises from the outer side of the os calcis, and is inserted into the tendons of the flexors digitorum and hallucis.

The tibialis anticus has but one tibial head, and was inserted into the metacarpal bone of the hallux. The extensor hallucis has a fibular origin, into and is inserted the aponeurosis of the first phalanx of the hallux. The extensor digitorum longus arises from the outer condyle of the femur by a strong tendon; it splits at once into four tendons which are inserted into the four outer toes.

The peronei (longus, brevis, and quinti) were as usual; the peroneus longus has an origin from the external lateral ligament as well as from the head of the fibula; it passes through a separate groove behind the malleolus.

The extensor brevis digitorum arises from the astragalus, and has four tendons to the four inner toes. The abductor ossis metatarsi minimi digiti is large, and the interossei are bicipital abductors of the index, medius and annularis, one headed adductors of index, medius annularis and minimus.

There are separate abductors for the hallux and minimus, a flexor brevis minimi digiti and an adductor hallucis; the tendons for the third, fourth, and fifth digits have accessory lumbricales.

The following notes of the visceral anatomy of the animal are worthy of tabulation:—

The Stomach was simple. The cardiac pouch rugose with scattered glands. The pyloric end of the stomach was smooth, beset with numerous adherent crystals. The bileduct opens into the duodenum an inch below the pylorus. There were no parasites in the alimentary canal. The length of the intestinal canal is 9 ft. 8 in. There is no cœcum, nor anal glands. The liver is seven lobed as usual in carnivora, with the two laterals small, the left being more detached than the right. The gall

bladder is large. The spleen is elongate, $4\frac{1}{2}$ in. long and $\frac{3}{4}$ in. wide, and being on the left side of the great omentum. The kidneys lobular, $2\frac{1}{2}$ in. long, and $1\frac{1}{2}$ in. wide, upper edge and front surface flatter. The hilus is wide and posteriorly directed, each lobule having an independent infundibulum. The ovaries are not encapsulated. The Fallopian tubes are about 4 inches long. The transverse mesocolon and the ascending layers of the great omentum are more united than in the common otter or badger. The mesocolon and mesentery have a single root. The pharyngeal walls are lined with thick rugose mucous membrane. The velum is rounded with no uvula, tonsils are sheltered behind valvular folds with their concavities backwards, a number of elongate papillæ are arranged along the sides of the palato-glossal folds. The tongue is smooth with a median depressed raphe, circumvallate papillæ are more numerous on the right side than on the left; a minute circumvallate papilla is in place of the foramen cœcum. The entire surface of the tongue is closely beset with fungiform papillæ; its front edge is semicircular, thin, sharp, serrated by the prominence of the papillæ, not emarginate. The length of the tongue is about 3 inches, the inferior surface being free for about half an inch. The ceratohyal on the right side was sharp and presented an adventitious angle.

The middle constrictor of the pharynx and sternohyoid are inserted into the thyrohygal cornua, and the stylo-ceratic fills up the angle between the two cornua. Thyroceratic is in front of the superior laryngeal nerve. The crico-thyroid is very extensive, but made up of short fibres. The inferior constrictor of the pharynx is very thick; crico-arytenoideus posticus is very large; the hinder edge of the cricoid cartilage is carinate. The true vocal chords are very sharp, the chink of the glottis narrow, the ventricle of the larynx small, no sacculus laryngis. The false vocal cords are small folds. The epiglottis is triangular, having the frænum attached nearly to its apex; the inferior cornua of the thyroid cartilage are long, curved, firmly attached to the side of the cricoid. The crico-arytenoideus lateralis is small. The thryro-arytenoid much larger. The lower part of the larynx is very wide, suddenly narrowing to the chink of the glottis; the cuneiform body is a soft connective lobule, external to the corniculum of the arytenoid; arytenoideus proprius is weak; the first ring of trachea is imperfectly double, and on the right side short, all the other rings make seven-eighths of a circle. There are 54 rings in the trachea; the upper bronchus comes off on the right side almost at the level of the bifurcation. The right lung consists of the three ordinary lobes and the azygos lobe, the latter being double; its two parts are separated by the vena cava inferior and phrenic nerve; the left lung is bilobed. The pericardium is perfectly free from the diaphragm. The heart is oblong, not sharply triangular. There is a long right superior vena cava and no left, a very large vena azygos; no vestigial fold of Marshall; a cylindrical inferior vena cava. The aorta gives off an innominate, from which arise the two carotids and the right subclavian. The inferior vena cava is a little dilated at its opening. The greater Eustachian valve is

very slight; the Thebesian valve larger; sinus of Read is not very large. The foramen ovale is closed, but in the left auricle the upper edge of the crescentic valve is not attached, and allows of a blow-pipe being introduced for a short distance.

MUSCLES OF THE FORE LIMB.

1. Trapezius,	scapularis inferior,	0·14
	scapularis superior,	0·14
	clavicularis,	0·47
2. Sterno-mastoideus,		0·38
3. Cleido-mastoideus,		0·19
4. Omo-atlanticus,		0·17
5. Rhomboideus, major, minor and occipital,		0·24
6. Teres major,		0·12
7. Latissimus dorsi,		0·27
8. Subscapularis,		0·38
9. Pectoralis major,	superficial part,	0·5
	deeper,	0·87
10. Deltoideus scapularis,		0·06
11. Deltoideus acromialis,		0·06
12. Deltoideus clavicularis,		0·18
13. Supraspinatus,		0·35
14. Infraspinatus,		0·2
15. Serratus magnus,		0·71
16. Biceps humeri (scapularis),		0·13
17. Brachiæus,		0·11
18. Triceps longus,		0·58
19. Triceps internus,		0·15
20. Triceps externus,		0·33
21. Triceps accessorius,		0·22
22. Anconeus externus,		0·04
23. Anconeus internus,		0·04
24. Pronator radii teres,		0·09
25. Flexor carpi radialis,		0·04
26. Palmaris longus,		0·11
27. Flexor carpi ulnaris,	olecranal,	0·13
	condyloid,	0·03
28. Flexor digitorum sublimis,		0·08
29. Flexor digitorum profundus,		0·25
30. Flexor pollicis longus,		
31. Pronator quadratus,		0·03
32. Supinator radii longus,		0·15
33. Extensor carpi radialis longior,		0·09
34. Extensor carpi radialis brevior,		0·10
35. Supinator radii brevis,		0·04
36. Extensor digitorum longus,		0·06
37. Auricularis,		0·02
38 Extensor carpi ulnaris,		0·08
39. Extensor ossis metacarpi pollicis,		
40. Extensor secundi internodii pollicis et indicis,		0·03
41. Extensor tertii et quarti digiti,		0·03

MUSCLES OF THE HIND LIMB.

1. Sartorius,	0·26
2. Psoas parvus,	0·13
3. Psoas magnus,	0·16
4. Pectineus,	0·07
5. Adductor primus,	0·33
6. Adductor secundus, α,	0·22
7. Adductor secundus, β,	
8. Adductor tertius,	0·18
9. Quadratus femoris,	0·03
10. Obturator externus,	0·13
11. Obturator internus,	0·07
12. Agitator caudæ,	0·14
13. Glutæus maximus,	0·06
14. Pyriformis,	0·08
15. Gluteus medius,	0·40
16. Gluteus minimus,	0·07
17. Gluteus quartus,	0·01
18. Tensor vaginæ femoris,	0·06
19. Biceps femoris,	0·48
20. Bicipiti accessorius,	0·10
21. Semimembranosus,	0·35
22. Semitendinosus,	0·22
23. Gracilis,	0·16
24. Rectus femoris,	0·34
25. Vastus externus,	0·45
26. Vastus internus,	0·17
27. Cruræus,	0·04
28. Popliteus,	0·08
29. Gastrocnemius externus,	0·22
30. Gastrocnemius internus,	0·34
31. Plantaris,	0·22
32. Soleus,	0·05
33. Flexor digitorum longus,	0·06
34. Flexor hallucis longus,	0·17
35. Tibialis posticus,	0·07
36. Tibialis anticus,	0·23
37. Extensor hallucis,	0·03
38. Extensor digitorum longus,	0·11
39. Peroneus quinti,	0·04
40. Peroneus brevis,	0·06
41. Peroneus longus,	0·06

N. B. For Figures illustrative of this Paper, see Plates xxx. xxxi. and xxxii., also explanation thereof.

L.—On an Inverted Lunar Halo, and a Lunar Rainbow. By Henry Hennessy, F.R.S., M.R.I.A.

[Read December 8, 1873.]

On the night of Sunday, December 15, 1872, a short time before 10 P.M., I noticed a faint white circular arch, not far above the horizón, to the N.N.W., and directly opposite to the moon's place. It was probably about 70° from the moon, and had its concave side upwards, as represented in Plate xxxiii.* It was decidedly eccentric to the moon, and could not come within the class of any of the ordinary halos, of which the maximum diameter, passing through the moon, would be 90°, and therefore the distance of a part of the luminous circle 45°. This diameter is one, moreover, very rarely seen, and from the appearance of the luminous arch here described, its diameter could not exceed 45°. The moon was at this time 15 days old, and very near the zenith, from which it was shining brightly on the light clouds in the direction of the luminous arch, although it was partially obscured itself behind a cloud which covered its disc.

The position of this arch with reference to the moon, namely, with its concavity turned towards the luminary, shows that it belongs to the class of halos, and notwithstanding its distance, it could not be considered as a lunar rainbow. It was totally unlike the very remarkable halo described in the Proceedings of the Academy, vol. iii. p. 18, by the Rev. Provost Lloyd and Mr. Clibborn; nor can I find a description of anything precisely similar on consulting the writings of many other observers of such phenomena. Dr. Lloyd remarks in his paper, that it would be interesting to multiply the records of such phenomena, so as to be able to trace the extent and limits of the cloud near the moon's place, in connexion with which halos are usually observed. As in this case the cloud which exhibited the phenomenon was distant from the moon, all the facts of the case show that it could arise only from a peculiar refraction, accompanied by some reflection, of the luminous rays, which it is not easy to trace with precision in the absence of exact angular measurements.

In order to trace the connexion, if any, between this phenomenon and the state of the weather at the time it was observed, I consulted the records of the Observatory at the Phœnix Park, as published by the Registrar-General, with the following results:—

* The portions dotted represent the outline of the halo, if it were complete.

December, 1872.

	Bar.	Ther., max.	Ther., min.	Mean.	Humidity.	Rain.
SAT., 14,	29·629	44·0	40·0	42·0	·843	·135
SUN., 15,	29·838	43·2	35·8	40·1	·945	·008
MON., 16,	29·561	46·0	34·8	40·4	·956	·970

From this it appears that the barometer rose on Sunday, while the humidity of the air was notably increased. The afternoon of Sunday was also very clear. These circumstances were favourable to abnormal phenomena of refraction. On Monday, the thick fog and heavy rain, which was collected to the amount of nearly an inch, were probably produced by the precipitation of the excessive vapour held in invisible suspension by the air at the time the inverted halo was seen.

LUNAR RAINBOW.

On November 29, 1873, at about 35 minutes after 7 P.M., a lunar rainbow was observed at Sandymount. It occupied the northern portion of the sky, which was clouded, and it appeared to stretch from a little below Ringsend towards the north part of Dublin. The prismatic colours were unusually well exhibited, showing that it must have been produced by a shower made up of large rain-drops. The whole day was warm and showery, with strong gusts of wind from the west. At the time this phenomenon was seen, a slight shower was falling, and the moon was bright, although only between half and three-quarters. In this instance the rainbow lasted about ten minutes. I have been informed that a similar lunar rainbow was seen on the same evening, at a somewhat earlier hour, from Booterstown.

The mean temperature (52°) and humidity of the air (·935) were abnormally high on the 28th, both had decreased on the 29th. The mean temperature of Friday was 2° higher than the mean annual temperature for Dublin.

LI.—REPORT ON THE STRUCTURE AND MODE OF LIFE OF HYALONEMA LUSITANICA BOCAGE. By EDWARD PERCEVAL WRIGHT, M. A., M. D., F. R. C. S. I., F. L. S., Professor of Botany in the University of Dublin.

[Read January 27th, 1873.]

WHILE on my way to the Seychelles Islands, in April, 1867, my friend, Dr. J. E. Gray, showed me in the British Museum a very beautiful specimen of the species of Hyalonema, called *H. lusitanica*, by Professor Barboza du Bocage, which was said to have been taken off the coast of Portugal, near Setubal. This new species had been described by Professor Bocage some three

years previously in the Proceedings of the Zoological Society of London for 1864 (page 265, Plate XXII.); and, although the discovery seemed, at the time, extremely well authenticated, yet it appeared so strange that a form up to then only found in the Japanese seas should occur on the coast of Europe, that there were not wanting some who thought the specimens might have made their way in some form or another to Portugal from Japan.

In November, 1865, Professor Bocage, in recording the occurrence of two fresh specimens taken off Setubal, writes:—" Maintenant j'espère que la nouvelle espèce de Hyalonema restera définitivement acquise à la fauna du Portugal."

Dr. E. J. Gray, having examined the form from Portugal, was satisfied that it and the one from Japan should be placed in different genera, and retaining the genus Hyalonema for the Japanese specimens, he proposed that of Hyalothrix for the Portuguese one. The "glass rope" he still regarded as portion of the axis belonging to as well as supporting the crown of Parasitic Polyps, believing that the basal sponge portion (Carteria) was a separate and distinct form.

Dr. Bowerbank (Proceedings of the Zoological Society of London, 1867, p. 18) gave a very detailed history of *Hyalonema mirabile*, accompanying it with several references to *H. lusitanica*, which he thought probable would prove to be one and the same species. He also states as his mature conviction, that the Polyps were but oscula of the great Cloacal organ (the glass rope stem), and expresses his belief that the whole of the structures present in the more perfect specimens of Hyalonema were parts of one and the same animal.

There were thus in the Spring of 1867 two very interesting questions to be decided as to the Portuguese species of the genus Hyalonema. Under what conditions was it found *in situ*, for Professor Bocage had been unable to investigate this matter himself; and, secondly, the question to be answered by the same practical investigation that would answer the first queries as to the parasitism of the Polyps, the so-called oscula of Bowerbank. Of both of these I took a note, with some faint hope that I might come across some species of the genus in the seas around the Seychelles. A want of energy for dredging work in my African boatmen, and a want of sufficient rope, prevented me from dredging, however, at any great depth in these tropical regions, and no trace of Hyalonema was met with in the comparatively moderate depths in which I dredged. On my return home in January, 1868, my attention was once again called to the subject, by receiving from my friend, Professor Lovén, of Stockholm, a copy of his Paper:—" Om en märklig i Nördsjon lefvande art af Spongia." Œfversigt af K. Vetenskaps Akademiens Förhandlingar, Arg. 25, in which, describing a little stalked siliceous sponge, Professor Lovén shows that the opinion of all previous writers, as to the relative position of the large sponge mass, and glass rope, in Hyalonema, must be erroneous, and states his belief that when Hyalonema is dredged in a living state, it will be found with its coil immersed in the

mud or sand. How opposed this view was to all previous ideas on the subject, is well shown by the published remarks of Dr. J. E. Gray, who says, in answer to a note from Professor Lovén, stating—"You will see that, if I am not very wrong, all who have treated of the Hyalonema have *inverted* it, turned it upside down, and that the twisted rope, instead of rising out of the sponge, in reality is nothing but the remaining part of the stalk,"—"Dr. Lovén has had, I fear, only very imperfect specimens of the Japan Hyalonema to examine, or he would not have adopted such a theory."

Thus one other query was added to the previous two, and all three were, in the Spring of 1868, to be answered only by a practical examination into the life-history of Hyalonema. I thought at once of trying to settle this; but it was not until the Autumn of 1868, that having been asked by the Academy to attempt the solution of these queries, I proceeded, on the invitation of Professor Barboza du Bocage to Lisbon, arriving there in August, 1868. I have narrated elsewhere (Annals and Magazine of Natural History, December, 1868) some of the details of my visit, and of the fish and corals to be met with at the great depth of 300 to 400 fathoms off the coast of Portugal to the south-west of Setubal. Here it will be sufficient to state that I have solved the questions asked by the Academy; and to report—

1. That, although I had with me only a small sized naturalist's dredge, yet that I succeeded in dredging from a depth of, I believe some 400 fathoms.

2. That the dredge brought up vast quantities of the large and long siliceous spicules characteristic of Hyalonema.

3. That I obtained one living and perfect specimen of the *Hyalonema lusitanica* of Bocage.

4. That, as suggested by Lovén, I proved that it lives with the long siliceous spicules of its stem anchored in the mud, and with the expanded portion of the sponge crowning the summit of the glass rope.

5. That the Polyps, as was indeed believed by almost all zoologists, were truly a species of Palythoa, partially expanding their tentacles, and behaving in every way like true Zoantharia.

6, And, lastly, to confirm the opinion of Professor Bocage, that the *Hyalonema lusitanica* was really a species indigenous to Portugal.

[Added January 27th, 1873.]

The Report as above was drawn up, and ready to be presented to the Academy (in November, 1868) within six months after it did me the honour of asking me to report on this subject. But at this very time I learned of the great success that had attended the deep sea exploring expedition under my friend Professor Wyville Thomson in the "Lightning." Through his kindness I was also enabled to behold some of the vast stores he had accumulated in this expedition, and found, among other things, numbers of Hyalonema. Satisfying myself with the record of my independent discovery of the

above recited facts, I waited to report further on the structure and life history of Hyalonema, until I would have the benefit of Professor Wyville Thomson's then expected memoir on the subject. Engaged now in exploring the deeply seated beds of the oceans of the globe, he is not likely for years to come to have time or leisure to return to this subject. When he does, doubtless, the results of his great experience will totally eclipse all that has hitherto been done in reference to the vitreous sponges. In the meanwhile the publication of this brief Report is called for by the Academy, and it may help to make good a series of facts now indeed but little disputed, and some of which have since been so well established that one is apt to forget how very long they were held in the category of very doubtful statements.

LII.—Screw Coordinates and their Applications to Problems on the Dynamics of a Rigid Body. By Robert Stawell Ball, LL. D., F. R. S. (Abstract).

[Read, January 12, 1874].

Screw coordinates are an adaptation to physical purposes of Dr. Felix Klein's* coordinates of a linear complex referred to six fundamental complexes of which each pair are in involution.

The present paper is an application of screw coordinates to the development of the theory of screws.†

The word Dyname is employed (Pluecker, Neue Geometrie des Raumes, p. 24) as a generic term to include what in the language of the present theory are severally known as wrenches, twists, or twist velocities.

If a dyname of one unit about a screw a be decomposed into components a_1 &c. a_6, about six coreciprocal screws, then the six quantities a_1 &c., a_6 are the coordinates of a.

If s_1, &c., s_6 be the pitches of the six coreciprocal screws of reference, then the pitch of a is

$$s_1 a_1^2 + s_2 a_2^2 + s_3 a_3^2 + s_4 a_4^2 + s_5 a_5^2 + s_6 a_6^2$$

For kinetic purposes the group of coreciprocals which are most natural, are the six principal screws of inertia.

If a free and quiescent rigid body receive an impulsive wrench about a principal screw of inertia, then the body commences to twist about the same screw.

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* Mathematische Annalen, Band ii., p. 204.

† Transactions of the Royal Irish Academy, vol. xxv., pp. (157-217), Philosophical Transactions, 1874.

The kinetic energy of a body twisting about the screw α with the twist velocity $\dot{H}\alpha$

is $$M(\dot{H}\alpha)^2(s_1^2\alpha_1^2+s_2^2\alpha_2^2+s_3^2\alpha_3^2+s_4^2\alpha_4^2+s_5^2\alpha_5^2+s_6^2\alpha_6^2)$$

If a body receive an impulsive wrench about the screw $\bar{\alpha}$, whose coordinates are proportional to

$$s_1\alpha_1,\quad s_2\alpha_2,\quad s_3\alpha_3,\quad s_4\alpha_4,\quad s_5\alpha_5,\quad s_6\alpha_6,$$

then the body commences to twist about an instantaneous screw α.

The condition that the screws α and β be reciprocal is

$$s_1\alpha_1\beta_1+s_2\alpha_2\beta_2+s_3\alpha_3\beta_3+s_4\alpha_4\beta_4+s_5\alpha_5\beta_5+s_6\alpha_6\beta_6=0$$

The conditions that n screws shall form a complex of a lower order can be expressed by the evanescence of a single function of the coordinates.

The partial differential coefficients of the pitch of a screw with respect to the coordinates are proportional to the coordinates of the corresponding impulsive screw.

If ρ be an impulsive screw, we find the corresponding instantaneous screw selected from the screw-complex (III. 1), as follows:

Draw the reciprocal plane to ρ, and find the diameter of the ellipsoid of equal energy, which is conjugate to the reciprocal plane, then the screw of the complex parallel to this diameter is the screw required.

If a rigid body have five degrees of freedom, then the principal screws of inertia are determined as follows.

Let η be the screw reciprocal to the freedom, then the coordinates of one of the principal screws of inertia are proportional to

$$\frac{\eta_1}{s_1-v},\quad \frac{\eta_2}{s_2-v},\quad \frac{\eta_3}{s_3-v},\quad \frac{\eta_4}{s_4-v},\quad \frac{\eta_5}{s_5-v},\quad \frac{\eta_6}{s_6-v}$$

where v is one of the five roots of the equation,

$$\frac{s_1\eta_1^2}{s_1-v}+\frac{s_2\eta_2^2}{s_2-v}+\frac{s_3\eta_3^2}{s_3-v}+\frac{s_4\eta_4^2}{s_4-v}+\frac{s_5\eta_5^2}{s_5-v}+\frac{s_6\eta_6^2}{s_6-v}=0$$

LIII.—Note on additional Instances of the Tidal Floatation of Sand. By Henry Hennessy, F. R. S.

[Read December 8, 1873].

I venture to communicate to the Academy a few additional instances of the curious phenomenon which I have described in detail, and explained as an illustration of known physical laws in my paper read April 10, 1871, which is printed in the Proceedings, *ante*, p. 153.

On June 11, 1872, I observed fragments of shells with small sand at Merrion, about 1 o'clock P. M., floating with the rising tide. The day was calm and the water smooth, otherwise the conditions were not very favourable. I present specimens of some of the flat fragments of shells which were seen thus floating. They readily sink on being completely wetted.

On May 11, 1873, at 9 o'clock, A. M., I observed the tide rising rapidly on the strand near Sandymount, and carrying with it broad patches of sand mingled with a few small flat pebbles, broken flakes of shells, and bits of slate.

The morning was bright, warm, and very calm, thus presenting all the conditions favourable to the phenomenon.

I have been informed by Mr. G. H. Kinahan, M. R. I. A., of the Geological Survey, that he has noticed the floating of sand with the rising tide at Killery bay, on our west coast. Although there was surf outside the bay at the time, the water where the sand was seen floating was calm.

The same observer informed me that he noticed a similar phenomenon at Manin bay and at Ballyconeely bay. He saw sand carried far up the estuary close by Owney Island, near Clifden.

These instances, in addition to those already mentioned in the Proceedings, prove that the floatation of sand by the tide is not a rare and accidental phenomenon, but probably one of frequent occurrence, and therefore, of geological and geographical interest.

See Proceedings, *loc. cit.*, also for April 8, 1872, *ante*, p. 252.

LIV.—SOME THEOREMS IN THE REDUCTION OF HYPER-ELLIPTIC INTEGRALS. By JOHN C. MALET, A. M. (Abstract.)

[Read January 12, 1874.]

IN the first part of the present paper I prove a theorem due to Professor Gudan, and show that from this theorem the relations given by Jacobi among the moduli of hyper-elliptic integrals of the first class, for which they may be reduced to elliptic functions, and the other relations subsequently discovered, all follow by one uniform method; in fact having proved one relation, the other two follow by an interchange of suffixes.

I then generalize Professor Gordan's theorem, and from this generalization prove that hyper-elliptic integrals with $2m - 3$ moduli may be reduced to similar integrals with $m - 1$ or $m - 2$ moduli, according as m is even or odd, provided that certain equations connecting the moduli are true.

There are three distinct set of equations among the moduli for which this theorem is true, and as in the case of the first class of hyper-elliptic integrals, being given one set of relations for which the theorem is true, the others follow by a mere interchange of suffixes.

The last part of the paper is occupied with the consideration of a certain hyper-elliptic integral with five moduli, which I have shown may be expressed as an elliptic function. The formula I have given for its reduction leads to generalizations of many important theorems in the theory of elliptic functions.

LV.—On some Improvements of the Comparable Self-Acting Hygrometer, which registers the Maximum and Minimum of Humidity and Siccity of the Atmosphere in the Absence of an Observer. By M. Donovan, Esq.

[Read 13th April, 1874.]

Since my last communication was presented to the Academy, I have endeavoured to remedy a deficiency in the instrument therein described. It registers the first two rounds of the index over the graduated circle, but does not register, although it measures the rounds which the index may subsequently perform. I now supply that deficiency.

The exsiccated gut-line of the hygrometer when in its place, one end fixed motionless by the clamp-screw, and the other at liberty, will begin to move the index in damp air* with its maximum motive power. But this force acts with decreasing effect the nearer the acting portion of the line is to the fixed point where it is null. From this consideration, it appeared that if several indexes were affixed to the gut-line, at different heights from the dial, all pointing in the same direction, they would, in revolving, all point differently, and would complete their revolutions in different times. This is actually the case, as I found by a confusing experiment made with five paper indexes fastened at equal distances on the gut-line.

From these facts I inferred that an index could be contrived which, besides moving over the graduated circle in the usual manner, might be adjusted to any position, higher up on the gut-line, without obstructing or interfering with the indications of the whole line, and that thus results might be obtained analogous to those exhibited by the hour-hand and minute-hand of a watch.

I effected this object by attaching a secondary index to the gut-line in such a manner as to permit the latter, while twisting and untwisting throughout its whole length, to turn both indexes at once, but at the different rates which belong to the two places on the gut-line to which they are attached. By such means, would be obtained movements similar to those of the hands of a watch.

Such a secondary index may be easily contrived: let a disc of that substance called "India-rubber *sheet*," about a quarter of an inch in diameter, and a tenth in thickness, be perforated through its centre by a sewing needle a little thicker than the gut-line intended

* During wet weather accompanied by high winds this hygrometer, as well as others formed of animal or vegetable substances, will be but little affected.

to be used; and, the needle being removed, let the end of the gut-line be passed through the perforation. Then let a thin wire, hooked at one end and sharpened at the other, be pushed into the disc, at a right angle with the gut-line. The wire is to be of such length that the hook will project directly over the graduation of the circle. From the hook is to be suspended, by a loop, a piece of the finest spool cotton, with the smallest particle of lead at the end to secure verticity, the cotton being of such length that the lead, in revolving, can at all times pass over the primary index. This constitutes the secondary index, which may be occasionally used or laid aside: it represents the hour-hand of a watch; the primary the minute-hand: its place is variable on the gut-line.

India-rubber is well fitted for this use as it takes sufficient hold of the gut-line to secure its remaining at the required height, while it does not hold it so fast as to prevent its twisting or untwisting, and at the same time turning the secondary index round. In some states of the weather it loses, but recovers its power.

By this arrangement, the secondary index will, independently of the primary, be carried round the graduated circle; and its pendent particle of lead will point downward exactly to the degree on the dial over which the secondary index at that moment stands. If the gut-line be viewed from a lateral position such that it shall cover the cotton thread, the degree on the dial, at that moment cut by the line, will be exactly seen, provided that the instrument stand vertically on a truly horizontal plane.

That the secondary index does really act in the capacity specified, and is turned by the gut-line, in damp air, according to the degree of motive power which belongs to the portion of the gut-line to which it is attached, is obvious from the fact that if it do not so act, it should turn with, and exactly at the same rate as the primary index, which it never does; and that, in returning in dry air, it retraces retrogradely the degrees over which it had passed during its progress forward.

I now proceed to show in what manner the secondary index keeps an account of the number of rounds (each 100°) completed by the primary during a lengthened period of moist weather. If the secondary index revolved at an equal rate with the primary, the required information could not be obtained; but they cannot revolve at an equal rate, for the secondary stands higher on the gut line than the primary, and it has already been observed that the motive force of the gut-line acts with decreasing energy the nearer the acting portion is to the fixed point where it is null, viz. at the clamp-screw.

When the length of gut-line exposed to damp air, from the clamp-screw which confined it, to the upper apex of the double cone was $2\frac{14}{20}$ inches, and the distance from the clamp-screw to the secondary index was $\frac{13}{20}$ inch, the latter measure being included in the

former, the following results were obtained: both indexes had been brought to zero.

Primary index	completed	100°	while secondary	traversed	30°
,,	,,	200	,,	,,	60
,,	,,	300	,,	,,	94

When the secondary index had traversed 94°, the primary had passed over 300°. But the case was very different when the length of gut-line exposed was $4\frac{1}{2}$ inches, and the distance of the secondary index to clamp same as before.

					Differences.
Primary index	completed	100°	Secondary	11°	11°.
,,	,,	200	,,	22	11
,,	,,	300	,,	31·5	9·5
,,	,,	400	,,	43	11·5
,,	,,	500	,,	56	13
,,	,,	600	,,	69·5	13·5
,,	,,	700	,,	83	13·5
,,	,,	800	,,	97	14

On one occasion, when the gut-line exposed was 4·65 inches, of which $\frac{3}{8}$ inch was the distance of the secondary index from the clamp-screw which held the gut-line.

					Differences.
Primary index	completed	100°	Secondary	10°	10°.
,,	,,	200	,,	20	10
,,	,,	300	,,	29	9
,,	,,	400	,,	39	10
,,	,,	500	,,	50	11
,,	,,	600	,,	58	8
,,	,,	700	,,	70	12
,,	,,	800	,,	80	10

In the first case, the primary index completed the circuit of the graduated dial three times, while the secondary went round once; for 94° could be recorded only once in a circuit of 100°. In the second case, the primary index completed eight circuits, while the secondary made the circuit once, and could do no more.

It may be seen, by these statements, that the untwisting of the gut-line is not equable, but is nearly so. The differences 9.8.12 vary from the average; yet no mistake can arise from inspection of the hygrometer: for if the secondary index stand at 29° or 39° or 58° on the graduated circle, the observer will know that these numbers can mean no other than 30°, 40°, or 60°, although a little unevenness in the twist of the gut-line causes a trifling disagreement, but for which the differences throughout would have been 10°.

It is easy to know how many rounds of the dial the primary index has performed, during the absence of an observer, by the indication of the secondary: the first digit of the decade last passed or now passing over, by the secondary index is the number of rounds already traversed by the primary, the constituent moisture of which is still present in the gut-line; and this digit, along with the number shown by the primary index at the same time, gives at a glance the moisture of the atmosphere at that present moment; and also the fraction of saturation, the denominator being 1000. Thus, on returning, after an absence, if I find the secondary index perhaps at or about 60° and the primary at 50°, I learn that the primary index has completed six rounds and a half; and that the constituent quantity of water, still present in the line, should be taken into account in the next observations, or else removed by exsiccation.

In noting the performance of the secondary index, its distance on the gut-line from the point where the latter is confined by the clamp-screw, must be also noted, that being an essential element of the observation. When the secondary index was attached to the gut-line, exactly midway between the apex of the cone and the clamp-screw, the primary index completed two rounds, while the secondary completed one, and both arrived at zero at the same time, they having started from that point.

It is often necessary, when making hygrometric experiments, to subject the hygrometer to an atmosphere saturated with aqueous vapour, which the natural atmosphere almost never is. In order to obtain such an atmosphere, I proceeded in the usual manner:—A glass cylinder, the lower half of which was lined with moistened blotting paper, was inverted over the hygrometer. The index began to move, and continued to do so for a while, but then stopped, although it was evident that the contained air was far from being saturated. I soon found that this discontinuance of the effect of the moistened blotting paper was dependent on the nature of the substance on which the glass cylinder was inverted. If on wood, the interruption took place; if on glass, the index continued to turn until the elasticity of the gut-line was exhausted. The cause of the difference is obvious: wood is an absorbent of moisture.

In experimenting with an artificial atmosphere the effect on the secondary index was not, in all cases, such as to produce equal differences. On five rounds of the primary index the differences shown by the secondary were the following:—

Primary	completed	100°	Secondary	10°	Difference	10°
,,	,,	200	,,	23	,,	13
,,	,,	300	,,	40	,,	18
,,	,,	400	,,	60	,,	20
,,	,,	500	,,	82	,,	22

This irregularity, I at length perceived, was dependent on the part of the glass cylinder occupied by the moistened blotting paper.

In the foregoing cases, where the differences increased from 10° through 13°, 18°, 20°, 22°, the moistened blotting paper occupied the upper half of the inverted cylinder; but on removing the moistened paper to the lower half, the order of the effects was reversed, the secondary index affording the descending series of differences 20°, 17°, 13°, 12°, 11°, 9°. The glass cylinder was 8 inches high, the hygrometer 5 inches, the cylinder of moist paper 3 inches. These details show in how small a volume of air an embarrassing difference of moisture may exist and derange the results.

It then occurred to me that, by placing the moist paper in the intermediate space between the two situations, the differences might make a nearer approach to equality. On making the trial, I obtained the following results, viz.:—

Primary	completed,	100°	Secondary,	12°	Difference,	12°
,,	,,	200	,,	24	,,	12
,,	,,	300	,,	38	,,	14
,,	,,	400	,,	50	,,	12
,,	,,	500	,,	62	,,	12
,,	,,	600	,,	72	,,	10

Here the differences may be considered virtually equal (average 12°), no other cause being assignable than the relative collocation of the moistened blotting paper; when this was at the bottom of the glass cylinder, the indications of the secondary index diminished from the top downwards; but when at the top, the indications increased from the top downwards; therefore, the most equable indications are obtainable when the moist paper is placed midway—a hint which may be made of more generally useful application.

Trifling irregularities in the twist of the gut-line occasion equivalent irregularities in the movement of the indexes. When there is any doubt or uncertainty about the digit of the decade indicated, the following may be employed:—Divide the known length of the portion of the gut-line intercepted between the India-rubber disc and the clamp-screw, into the whole length of the gut-line; the quotient is the total number of rounds of which the primary index is capable, between the extremes of siccity and humidity, which cannot exceed ten; and this quotient, divided into 100°, or one round of the secondary, gives the number of degrees of the secondary that are equal to one round of the primary index; which number, divided into a round of the secondary, gives as quotient the number of times which the primary index has gone round in the absence of an observer.

Between the results of the two methods there is frequently a discrepancy, perhaps due to the difficulty of knowing where in the gut-line the intercepted portion begins and ends within the disc of India-rubber. I have assumed the middle of the thickness of the disc as affording a result which cannot be far from the truth. When the length of the gut-line (including the intercepted portion) was 3·625

inches, and the intercepted portion ·56 inch, dividing the latter into the former, the quotient 6·47 is the number of rounds which the primary index should give, by calculation; but, by experiment, it gave seven complete rounds. The discrepancy is easily explained when we recollect that of two strings of any kind, the same in all respects, if one be moistened, it becomes shorter. As long as the length of the gut-line and the ratio of the intercept remain unchanged, the quotient of the division of the former by the latter may be used as a check on the indications of the two indexes; and being the natural unit, should measure the graduated circle.

From a number of experiments I give the results of a few to show how nearly the secondary index agreed with the results of calculation. In nine cases they agreed exactly; in three the difference was 1°; in four the difference was 2°; in three it was 4°; in three it was 5°; in six it was 6°. These differences are all explicable by the fact that in the experimental cases, moisture was concerned, and not in the calculated.

But in a journal where averages for the day or week are to be noted, such differences would all but disappear.

On making trial of a new gut-line to discover how much water it contained in what may be called its natural state (i. e., as procured from the music seller), I found that when confined in the receiver of the hygrometer with an exsiccating disc, the index went round twice; hence the necessity of exsiccation when a new gut-line is to be used for an important experiment.

The means of recording the maximum of moisture in the absence of an observer with this instrument are very simple. Wrap a piece of very thin soft iron wire round a common brass pin of the same thickness as the gut-line, in the form of a helix, consisting of four or five coils, so as to form a kind of hollow cylinder of wire, through which the gut-line is to pass, and to constitute an axis for the helix to turn on. The redundant wire at one end is to be cut off; and the redundant wire at the other end is to be bent away from the helix as a horizontal arm at a right angle with the gut-line, and again bent downwards at a right angle with the arm in such a part as will cause it to be encountered and carried forward by the secondary index when moving in a forward direction. But when the secondary retrocedes in consequence of drought, it leaves the iron wire index stationary to point to the maximum which it had reached during the absence of an observer.

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TO VOLUME I. OF THE PROCEEDINGS.

END OF VOLUME I.

APPENDIX.

APPENDIX.

MINUTES OF THE ACADEMY

FOR THE SESSION 1869-70.

NOVEMBER 8, 1869.

W. STOKES, M. D., F. R. S., Vice-President, in the Chair.

JOHN JOHNSTON KELSO, M. D., was elected Member of the Academy.

The correspondence with Lord Talbot de Malahide, respecting his proposed resignation of the Presidentship of the Academy, having been read:—

It was unanimously RESOLVED,—"That the Academy receive with great regret the announcement of the resignation of the office of President by the Right Hon. The Lord Talbot de Malahide.

"That the Secretary be requested to convey to his Lordship the grateful thanks of the Academy for the eminent services in its behalf rendered by Lord Talbot de Malahide, and for his dignified and efficient discharge of his functions as President of the Academy."

"That, the office of President of the Academy being now vacant, the Council be requested, at their next Meeting, to settle the Balloting List, in order that the Academy may proceed, at its Stated Meeting on the 30th November, inst., to elect a President."

The following Paper was read:—

"On the Ruins of Ardillaun, County of Galway." By G. H. Kinahan, Esq.

Donations were presented, and thanks voted to the several donors.

STATED MEETING, NOVEMBER 30, 1869.

THE RIGHT HON. THE EARL OF DUNRAVEN, F. R. S., &c., Vice-President, in the Chair.

A Letter from the Right Hon. Lord Talbot de Malahide, thanking the Academy, and conveying to its Members his best acknowledgments for the complimentary Resolutions of last Meeting, was read.

A Ballot having been taken, the Rev. J. H. Jellett, B. D., was elected President of the Academy.

The following Papers were read:—

"On certain Antiquities found in the Counties of Dublin, Londonderry, and Queen's County." By Sir W. R. Wilde, M. D.

"On a New Step in the Proximate Analysis of Saccharine Substances." By James Apjohn, M. D.

Donations were presented, and thanks voted to the donors.

December 13, 1869.

The Rev. J. H. Jellett, B. D., President, in the Chair.

The following recommendations, brought up by the Secretary of Council, were adopted:—

"To sanction the repayment to certain Guarantors of the sum of £60 9*s*. paid for photographing certain articles in the Academy's Museum."

"To grant the following sums out of Special Parliamentary Grant, for Reports, &c., on scientific subjects:—

1. To Rev. E. O'Meara, £30, to enable him to continue his Researches on the Irish Diatomaceæ.
2. To J. Bailey, Esq., £20, to carry out Experiments on "Flitch Beams."
3. To B. B. Stoney, Esq., to try Experiments on "Rivetted Joints."
4. To Henry Hennessy, F. R. S., £30, to determine the "Influence of the Molecular Condition of Fluids on their Motion, when in Rotation, and in contact with Solids."

Donations were presented, and thanks voted to the donors.

January 10, 1870.

Sir Robert Kane, F. R. S., Vice-President, in the Chair.

William Archer, Esq.; Robert S. Ball, M. A.; Robert Day, Esq.; Jun.; Sir John Esmonde, Bart., M. P.; Thomas A. Jones, President, R. H. A.; Rev. John P. Mahaffy, F. T. C. D.; Joseph P. O'Reilly, C. E.; were elected Members of the Academy:—

The following alterations in the By-Laws, recommended by Council, 3rd January, 1870, were adopted by the Academy.

That for Chap. I., 3. "The Council is divided into three Committees, each consisting of seven Members, which Committees have for their objects, respectively, the Departments of Science, Polite Literature, and Antiquities;"

be substituted:—"The Council is divided into two Committees; one consisting of eleven, the other of ten members—the former having for its object the Department of Science, and the latter those of Polite Literature and Antiquities."

That for Chap. II., 17. "There shall be three Sections of Honorary Members, corresponding to the threefold objects of the Academy, and the numbers in each Section shall be limited as follows:—Section of Science, 30; of Literature, 15; of Antiquities, 15; total, 60. And the one-half, at least, of Honorary Members in each Section shall be foreigners;"

be substituted:—"There shall be two sections of Honorary Members, and the number in each shall be limited as follows: Section of Science, 30; of Literature and Antiquities, 30; total 60; and one-half, at least, of the Honorary Members in each Section shall be foreigners."

That for Chap. V., 6, *b.* "This list shall be divided into three, each consisting of not less than fourteen names, containing the names of such persons as shall be deemed qualified to serve on the three Committees of which the Council is composed;"

be substituted:—"This list shall be divided into two Sections, the first consisting of twenty-two names, the second of twenty names, being those of such persons as shall be deemed qualified to serve respectively, on the Committee of Science, and on that of Literature and Antiquities."

That in Chap. V., 6, *e.* "The names of such Members as shall be found to have attended less than ten meetings of the Council (including *stated* meetings of any one Committee of Council) during the year, before the meeting at which the lists are prepared, and exclusive of that meeting (at which they shall have no seat), shall be omitted in the preparation of the list of forty-three names required by the Charter, and shall not be included in the Council of the preceding year, but shall be treated as if such Members had died or resigned; provided that, if any Member of Council shall have been elected in the middle of the year, he shall not be required to attend ten meetings in order to retain his place in the list, but only such a proportion of the whole number of meetings since his election, as the Council shall judge to be equivalent to ten out of the whole number;

[The Committees intended by the foregoing resolution are the Committees of Science, Polite Literature, Antiquities, Publication, Economy, and Library;]

after "the whole number," *be added:*—"Provided also that the Council shall have power to accept six attendances instead of ten, from non-resident members of the Council; non-residents being defined as persons residing at a distance exceeding twenty miles from the General Post Office. The number of Members to whom this privilege may be given shall not exceed four."

That the last sentence of Chap. V, 6, *e., be omitted.*

That in Chap. V., 6, *i.* "The President for the expiring year, if retiring from the Chair, in accordance with the recommendation of the

Academy (§ 4, *supra*), shall be considered as eligible to any one of the Committees of Council."

For "any one" *be substituted* "either."

That in Chap. IX., 4. "A Committee of Publication shall be nominated annually by the Council out of its Members, and shall consist of seven Members—three from the Committee of Science, and two from each of the other Committees."

For the words after "shall consist of," *be substituted:*

"Eight Members—four from the Committee of Science, and four from the Committee of Polite Literature and Antiquities."

The following Papers were read:—

"On a Fragment of a Block Book in the Library of Trinity College, Dublin." By Rev. B. Dickson, D. D.

"On the Illumination of Microscopic Objects." By John Barker, M.D.

Donations were presented, and thanks voted to the donors.

January 24, 1870.

The Rev. J. H. Jellett, B. D., President, in the Chair.

The following Papers were read:—

"On a Tumulus and Chamber, in the Island of Gaor Inis, Morbihan, Brittany." By Eugene A. Conwell, Esq.

"On the Small Oscillations of a Rigid Body about a Fixed Point under the Action of any Forces, and more particularly when Gravity is the only Force acting." By Robert S. Ball, M. A.

"On Microscopical Researches on the Atmosphere." By George Sigerson, M. D.

Donations were presented, and thanks voted to the donors.

February 14, 1870.

The Rev. J. H. Jellett, B. D., President, in the Chair.

Mark S. O'Shaughnessy, Esq., was elected a Member of the Academy.

The following Recommendations of Council were adopted:—

1. To grant to the Council out of the unappropriated balance of the present year in hands, the sum of £50 for Library purposes.
2. To grant to Professor King £25, to enable him to carry out his researches, "On the Jointing, Foliation, and Cleavage of Rocks."
3. To grant £25 to Professor Ball, to enable him to carry out his Experiments:—"On the Velocity of Smoke Rings in Air."

The following Papers were read:—

"Researches in the Application of Optics to Chemistry:—I. Combinations of Nitric Acid with Quinia." By Rev. J. H. Jellett, B. D.

"On Antiquities presented to the Museum." By W. F. De V. Kane, Esq.

"On an Ogham Inscribed Stone at Kiltera, Co. Waterford." By R. R. Brash, Esq.

Donations were presented, and thanks voted to the donors.

February 28, 1870.

Sir Robert Kane, M. D., Vice-President, in the Chair.

The following Papers were read:—

"On a proposed System of Suspension of a Barometer." By Professor O'Reilly.

"Supplementary Note on Eozoon Canadense, a Mineral Pseudomorph." By Professors W. King and Rowney.

Donations were presented, and thanks voted to the donors.

Stated Meeting, March 16, 1870.

The Rev. J. H. Jellett, B. D., in the Chair.

The following Report of the Council was read and adopted:—

Report.

At the close of another year, the Council have much pleasure in bearing testimony to the not merely continued but increasing prosperity of the Academy. There has been a larger than usual accession of new Members; the Treasurer reports that our financial condition is highly satisfactory; there has been an ample supply of Scientific, Literary, and Antiquarian Communications at our Meetings; and the amount of useful work carried out in the several Departments of our Institution has probably never been exceeded during any equal period.

The following Papers in our "Transactions," which, at the date of our last Report, were nearly ready for publication, were soon after completed, and issued:—

"On the Histology of the Test of the Palliobranchiata." By Professor W. King.

"On Bicircular Quartics." By John Casey, LL. D.

And "Contributions to the History of the Terebenes." By Mr. C. R. C. Tichborne.

The following have since been printed:—

"Contributions towards a Knowledge of the Flora of the Seychelles." By E. P. Wright, M.D.

"On a New Step in the Proximate Analysis of Saccharine Matters." By James Apjohn, M.D.

Vol. X., Part 4, of the "Proceedings," has just been completed, and will in a few days be in the hands of Members.

We have received Communications during the past year :—

In Science—From the President; Professor R. S. Ball; Dr. John Barker; Mr. Michael Donovan; Dr. Apjohn; Dr. Sullivan; Professor Hennessy; Dr. William Frazer; Professors W. King and Rowney; Dr. J. M. Purser; Dr. Sigerson; and Professor O'Reilly.

In Polite Literature—From Rev. Dr. Hume; Very Rev. Dr. Russell; and Rev. Dr. Dickson. A Paper by the late Rev. Dr. Wills has also been read before the Academy.

In Antiquities we have had Contributions from Lord Talbot de Malahide; Sir W. R. Wilde; Mr. W. F. de Visme Kane; Mr. G. H. Kinahan; Mr. R. R. Brash; and Mr. Eugene A. Conwell.

In the Department of the Library, the following works have been executed under the direction and personal superintendence of the Librarian :—A Draft Catalogue of all the Publications of Societies and Institutions in the Library of the Academy; a Catalogue of the Haliday Collection of Pamphlets in 8vo, from 1685 to 1859; the arrangement and (in part) cataloguing of the unbound Pamphlets in the same Collection, commencing in 1578. The extent of these works may be judged from the fact that the latter series comprises about 7000 Pamphlets, while the former amounts to 2211 volumes, containing a total of 21,907 Pamphlets. Each of these, with its imprint and number of pages, is entered in the Catalogue, which consists of eight volumes, folio. A volume has also been completed which shows in tabular form the number of Pamphlets on each special subject throughout the period over which the series extends. The Pamphlets now in the Academy's possession form a nucleus for a complete collection of literature of this class relating to Irish affairs down to our own time; and the Council will be happy to receive and preserve any additions to it which may be presented.

Progress is being made in supplying deficiencies in the sets of publications of Institutions, and a large amount of binding of works of this class has been executed.

The Council, in accordance with a recommendation of the Library Committee, have lately resolved to try the experiment, during the present Session, of keeping the Library and Reading Room open for readers until six o'clock, P. M., instead of till four o'clock, as heretofore.

In the Department of Irish MSS., much valuable work has been done. The continuation of the Descriptive Catalogue has been proceeded with. The Index to the Manuscripts and to O'Curry's Catalogue has been finally arranged, bound in 13 volumes, folio, and placed in the Library, where it is found of great advantage in inquiries connected with our Manuscript Collections.

The printing of the first Number of the Irish Manuscripts Series has been completed; and it will be issued in the present month.

At the instance of the Librarian, the Council have commenced the lithographing of Irish texts, which it is hoped will be attended with

important results in the promotion of Celtic studies. The first Manuscript selected for lithographing was the Leabhar na h-Uidhri, the most ancient and valuable Irish text (not ecclesiastical) now extant in these countries. An accurate and elegant lithographic copy—line for line—of this volume has been made by Mr. O'Longan; and it is with great satisfaction that we are able to announce that the entire is now on stones in proof, and will be printed off as rapidly as is consistent with careful final revision. The volume will be issued to subscribers at as moderate a rate as possible, to bring it within the reach of Celtic students at home and abroad.

The formation of a Museum on the first floor of the Academy House has been proceeded with, under the supervision of a Special Committee in communication with the architect of the Board of Works. The arrangements include the construction of a fire-proof room. The front drawing room (formerly the Council Room) has been rendered fire-proof by the introduction of a concrete floor and ceiling. This work will effectually protect the objects deposited in the room from all risk of fire. The fittings, consisting of iron presses, have been set up, and will afford space for the more precious objects of the Academy's Collections. In the long drawing room (formerly the tea room) the fitting-up of mahogany presses has been completed throughout the several wall spaces, and the trays and objects displaced from the old Museum have been re-arranged, as nearly as possible, in their former condition. When the glazing and internal fittings of the iron presses shall have been completed, and the gold ornaments, and rarer objects of the Collection, placed in a state of permanent security, the Museum will be in a proper state to be fully opened to the public. But this most desirable end cannot be attained without a large outlay for an increased number of attendants, and other expenses necessarily involved in the measure. Accordingly, in submitting to the Government the usual estimate of the sum required to be voted for the Academy for the next financial year, the Council included in the amount a sum of £200 to meet the cost of thus fully opening the Museum. We regret to say, that the reply received was to the effect, that the Lords Commissioners of Her Majesty's Treasury are not prepared to propose to Parliament an increase in the Academy's grant for the purpose above-mentioned.

A suggestion having been made to the Council by the Committee of Antiquities, that it would be desirable to have a selection of the articles in the Museum photographed, steps were taken to secure the services of a skilful artist. A number of admirable photographs of the most important objects in our Collection have been executed by Mr. Mercer. They will be published in a series of fasciculi, and will, it is believed, be most useful in supplying accurate representations of our antiquities to students at a distance, and in facilitating the comparison of Irish works of art with those of other countries.

The Members of the Academy have been enabled by the kindness of the Most Rev. Dr. Butler, and of Lord Dunraven, to examine the

beautiful chalice and brooches found at Ardagh. It appears to us in the highest degree desirable that these fine specimens of ancient Irish art should find a permanent place in our National Museum, where they can best be compared with other products of the same school, and where they will be accessible, whether for purposes of antiquarian study, or as models to act in the way of stimulation and suggestion on modern ornamental artists in this country. We have accordingly laid before the Government, through His Excellency the Lord Lieutenant, a memorial praying that the articles in question be purchased, and deposited in our Collection. We have included in the same application another interesting relic, the property of the representatives of the late Rev. Dr. Todd—namely, the ancient Bell, commonly called the Bell of St. Patrick, with the elaborate cover or shrine which contains it. The decision of the Government on the subject of this memorial has not yet been received.

No antiquities of importance have been offered to the Academy for purchase during the past year.

The Council have had under consideration the formation of a more complete Lapidary Museum than we now possess; and, in particular, the collection of a set of authentic casts of the chief Ogham inscriptions found in the British Islands; and they have resolved to place a grant, to be devoted to this purpose, at the disposal of the Committee of Polite Literature and Antiquities.

Out of the sum of £200 placed at the disposal of the Academy for the purpose of aiding the prosecution of scientific researches requiring expenditure on instruments or materials, the following grants have been made during the past year:—

1. To the Rev. E. O'Meara, for further Researches on the Irish Diatomaceæ, £30.
2. To Mr. J. Bailey, for Experiments on Flitch Beams, £20.
3. To Mr. B. B. Stoney, for Experiments on Riveted Joints, £20.
4. To Professor Hennessy, for Experiments to determine the Influence of the Molecular Condition of Fluids on their Motion when in Rotation and in Contact with Solids, £30.
5. To Professor King, for Researches on the Jointing, Foliation, and Cleavage of Rocks, £25.
6. To Professor Ball, for Experiments on the Velocity of Smoke Rings in Air, £25.

And it will be recommended to the Academy at the approaching Stated Meeting, to give its sanction to the following additional grants:—

7. To Dr. John Barker, for Experiments on Microscopic Illumination, £20.
8. To Dr. Emerson Reynolds, for Researches on the Spectrum Analysis of Chlorine, &c., £15.
9. To Dr. N. Furlong, for Experiments on the Innervation of the Heart, £15.

It is to be observed that the results of the researches thus aided are to be brought before the Academy, and published in its "Transactions" or "Proceedings." Gentlemen proposing to undertake scientific inquiries, and desiring to obtain assistance from the fund in the coming year, are requested to send in their applications at as early a date as possible.

In the beginning of June, 1869, Lord Talbot de Malahide informed the Council that in consequence of the state of health of a member of his family, it would probably be necessary for him to go abroad, and that he could not undertake to be present at any of the Meetings of the ensuing session. Being of opinion that the President of the Academy should personally watch over its interests, especially at a period so important in its history, he thought it his duty to place himself in the hands of the Council, and leave them free to act as they should judge best for the interests of the Institution. The Council received this announcement with much regret, and, hoping for an altered state of circumstances which would enable his Lordship to continue to hold the Presidency, took no action in the matter. In September, a letter was received from Lord Talbot, in which he stated that he found it would not be in his power to discharge the duties incumbent on him, and that he therefore felt bound to resign his office. This communication was brought before the Academy at its next meeting. It was received with feelings of deep regret, and with a unanimous expression of the gratitude of the Academy for the eminent services in its behalf rendered by his Lordship, and for his dignified and efficient discharge of his functions as President. At the Stated Meeting in November, the Academy proceeded to choose a successor to Lord Talbot; and the Rev. John H. Jellet, A. M., Fellow of Trinity College, and Professor of Natural Philosophy in the University of Dublin, was unanimously elected.

Not the least important event in the history of the Academy during the past year has been the change introduced in the constitution of the Council. It had for some time been felt that, considering the immense development which Science has received in recent times, and the great number of different branches of inquiry comprehended within its domain, the place which it ought to occupy in the work of the Academy was not adequately represented by assigning to it a representation on the Council amounting only to one-third of that body. At the same time it had been ascertained by the experience of many years that the number of communications to the Academy which could be regarded as coming under the head of Polite Literature was comparatively very small. There are now so many more popular vehicles through which papers on Literature can be brought before the public, that there is little inducement to offer them for insertion in the Transactions of a learned Society. Again, it has not been found easy to trace with accuracy the line of demarcation between the respective provinces of the Committees of Polite Literature and of Antiquities; and difficulty has sometimes been felt in determining to which of these fields a given contribution should be assigned.

For these reasons we proposed to the Academy, on the recommendation of a Committee which had maturely considered the subject, to alter the distribution of the Council into Committees, keeping, of course, within the limits prescribed by the Charter. The nature of the change consists in the increase of the Committee of Science to the number of eleven, and the union of the Committees of Polite Literature and Antiquities into one Committee, to consist of ten members. This proposition has received the sanction of the Academy; and a Council, constructed on the new plan, will be brought into existence by the election at the approaching Stated Meeting. It will, of course, be understood that nothing is farther from the wish or the intention of the Council, than to remove Literary Studies of a suitable character from their proper place amongst the objects of the Academy. Such an attempt would not only be highly inexpedient, but would be a direct violation of our Charter. To the joint Committee of Polite Literature and Antiquities will belong—as heretofore to those Committees separately—the subjects of Archæology, History, and Philology, in the widest acceptation of those terms. It is hoped that these great studies, which—though in our classifications we distinguish them from the sciences strictly so called, are now more than ever based on scientific principles, and prosecuted according to scientific methods, will attract a large share of the intellectual energies of our Members, and that there will be found in the Academy cultivators of these branches of learning worthy to be the successors of Hincks, Petrie, Todd, O'Donovan, and O'Curry.

We have lost by death ten Members within the year:

1. Alexander Boyle, Esq., elected 1838.
2. J. T. R. Colclough, Esq., elected 1854.
3. Sir Edward Conroy, Bart., elected 1839.
4. Charles P. Croker, M. D., elected 1834.
5. J. Beete Jukes, Esq., M. A., F. R. S., elected 1852.
6. Rev. Edward Marks, D. D., elected 1836.
7. James Patten, M. D., elected 1841.
8. Rev. James H. Todd, D. D. (ex-President), elected 1833.
9. Rev. Richard H. Wall, D. D., elected 1823.
10. Right Hon. John E. Walsh, elected 1855.

Two of these names it is impossible for us to pass by without special notice.

The many and various labours of Dr. Todd would well deserve to be recorded in a detailed biographical narrative. Here we can only briefly mention the leading facts of his career, and the services which he rendered to this Academy, and to the cause of our national literature. Born at Dublin in 1805, he graduated as Bachelor of Arts in Trinity College in 1825; obtained a Fellowship in 1831; was elected Regius Professor of Hebrew in 1849; and Librarian in 1852. He became a Member of the Academy in 1833; and from the beginning showed a

warm interest and took an active part in its labours. He devoted himself with zeal to the study of Irish history and archæology, and contributed to our "Proceedings" many papers on these subjects. He was one of the fellow-workers in that great movement for the restoration and reform of Celtic studies which marked the second generation of the present century in this country. He exerted himself particularly in procuring transcripts or accurate accounts of Irish manuscripts existing in foreign libraries—"endeavouring," in the words of Professor O'Curry, "to recover for his native country" as large a portion as possible "of her long lost and widely dispersed ancient literary remains." He was a liberal subscriber towards the purchase of antiquities for our Museum. He edited for the Archæological Society the Irish version of the "Historia Britonum of Nennius," with a translation and notes; and for the same Society, after its junction with the Celtic, the "Liber Hymnorum," the second fasciculus of which has appeared since his decease. He was also the author of the elaborate introduction to Mr. Crosthwaite's edition of the "Obits and Martyrology of Christ's Church," Dublin," and of that prefixed to Dr. O'Donovan's translation of the "Martyrology of Donegal;" and contributed several papers to the Miscellany of the Archæological Society. He edited the "Wars of the Danes and Norsemen in Ireland" in the series of historical works issued under the supervision of the Master of the Rolls in England. He also published many writings on theological subjects, which we need not here enumerate. Probably the work with which his name will be most durably associated is his "Memoir of the Life and Mission of St. Patrick," which, though containing much matter on which difference of opinion may be expected to exist, is universally admitted to have been the fruit of great research, and to exhibit profound and extensive learning.

During the latest period of his life he was occupied in conducting through the press two small treatises, which will form a part of the forthcoming First Number of our Irish Manuscripts Series.

Dr. Todd was first elected a member of our Council in 1837; he was Secretary of the Academy from 1847 to 1855; and in 1856 was elected to the Presidency, an office which he filled most efficiently, and with his characteristic courtesy and geniality of manner.

A movement has been set on foot for commemorating his services in the cause of Ancient Irish Literature by the establishment of a Professorship of the Celtic Languages in connexion with the Academy, and a considerable sum has been already collected by public subscriptions for this purpose. Whether as a just tribute to the memory of an able scholar and an active and zealous officer of our Institution, or as a foundation likely to further the progress of scientific philology in the department most interesting to Irishmen, this project deserves the earnest support of every friend of our National Literature, and the Council heartily commend it to the favourable consideration of the Members of the Academy.

Joseph Beete Jukes was educated at the University of Cambridge, where he was a favourite pupil of Professor Sedgwick. Having been

appointed Naturalist on the Surveying Voyage of H. M. ship "Fly," he had an opportunity of applying his rare powers of observation to the phenomena of Nature in the Tropics, and of adding considerably to the then existing amount of knowledge on the Coral Reefs of the North-East coast of Australia. He published in 1847 a work giving an account of this voyage. On his return he was employed in the English Geological Survey, and produced an excellent Monograph on the South Staffordshire Coal-fields. This work gave the author a high rank among geologists, and led to his appointment as a member of the Jevons Coal Commission. When, in 1851, Professor Oldham was placed at the head of the Geological Survey of India, Mr. Jukes was chosen to fill his place as Local Director of the Survey of Ireland. When Mr. Jukes came to this country there existed a profound difference of opinion between English and Irish geologists as to the relations between the Devonian and Carboniferous Rocks—the English geologists interpreting Ireland by the phenomena exhibited in a complex form and on a narrow scale by the rocks of Devonshire, while the Irish geologists insisted upon the Irish Rocks as being the true type of the entire Carboniferous system, and held that Devonshire, and such other restricted areas, must be interpreted from the larger and typical development of the Carboniferous series in the South of Ireland. Convinced by his own observations, and those of his staff, he became the warmest advocate of the views maintained by Irish geologists. He undertook to test the correctness of those views by personal observations in Devonshire, and his observations confirmed the opinions he had adopted. The results, which he published, both separately and in the "Journal of the Geological Society of Ireland," were cordially received by men of science, and the doctrine he maintained will, no doubt, ultimately be universally accepted. Mr. Jukes was marked by independence of character, great candour of mind, and the most sensitive honour. His social qualities won for him the warm attachment of his friends. His "Student's Manual of Geology," which has passed through several editions, is regarded as one of the best elementary treatises on that Science. He was, for some time, a Member of the Council of the Academy; and the following Papers from his pen appear in our "Proceedings and Transactions":—"On the Peak of Teneriffe," in Vol. VI.; "On the Lower Palæozoic Rocks of the South-East of Ireland;" and "On the Coexistence of the Human Race and Extinct Animals," in Vol. VII.; "On the Flint Implements found at St. Acheul," in Vol. VIII.

Nineteen Members have been elected during the past year:—

1. Maurice Lenihan, Esq., J.P.
2. A. M. O'Farrell, Esq.
3. Rev. J. O'Hanlon.
4. Rev. James O'Laverty.
5. George Sigerson, M.D.
6. C. R. C. Tichborne, Esq.
7. Very Rev. Jas. Kavanagh, D.D.
8. James H. O'Brien, Esq.
9. John C. O'Callaghan, Esq.
10. Sir Thomas Tobin.

11. John Johdston Kelso, M.D.
12. William Archer, Esq.
13. R. S. Ball, Esq., M.A.
14. Robert Day, Esq., Jun.
15. Sir John Esmonde, Bart.
16. Thomas A. Jones, Esq., President, R.H.A.
17. Rev. J. P. Mahaffy, F.T.C.D.
18. Joseph P. O'Reilly, Esq., C.E.
19. Mark O'Shaughnessy, Esq.

The following Recommendations of the Council of March 7 and 12, 1870, were adopted:—

I. "To recommend the Academy to allocate the sum of £20 to John Barker, M.D., to aid his Experiments 'On Microscopic Illumination.'"

II. "To recommend the Academy to allocate out of the unappropriated balance of the Parliamentary Grant in hand the sum of £15 to Dr. E. Reynolds, to enable him to carry out his Researches 'On the Spectrum Analysis of Chlorine, &c.' Also, to grant £15 to Dr. N. Furlong, to enable him to carry out his Experiments 'On the Innervation of the Heart.'"

The following Paper was read:—

"Supplementary Note on Two Streams flowing from the same Source in Opposite Directions," by Professor Hennessy.

The following President, Council, and Officers, were elected for the years 1870–1.

PRESIDENT.

Rev. J. H. Jellett, M.A.

COUNCIL.

Committee of Science.

W. K. Sullivan, Ph. D.
Henry Hennessy, F. R.S.
William Stokes, M.D., F.R.S.
A. Searle Hart, LL.D.
James Apjohn, M.D., F.R.S.
Rev. H. Lloyd, D.D., F.R.S.
Rev. S. Haughton, M.D., F.R.S.
Rev. Joseph A. Galbraith, M.A.
Robert MacDonnell, M.D., F.R.S.
E. Perceval Wright, M.D.
Robert S. Ball, M.A.

Committee of Polite Literature and Antiquities.

John T. Gilbert, F.S.A.
William H. Hardinge, Esq.
John Kells Ingram, LL.D.
Sir W. R. Wilde, M.D.
Rev. George Longfield, D.D.

Samuel Ferguson, LL.D.
W. J. O'Donnavan, LL.D.
Alexander G. Richey, LL.B.
Colonel Meadows Taylor, C.S.I., M.R.A.S.
John R. Garstin, LL.B.

TREASURER.—W. H. Hardinge, Esq.
SECRETARY OF THE ACADEMY.—W. K. Sullivan, Ph. D.
SECRETARY FO THE COUNCIL.—John Kells Ingram, LL.D.
LIBRARIAN.—John T. Gilbert, F.S.A.
SECRETARY OF FOREIGN CORRESPONDENCE.—Sir W. R. Wilde, M.D.
CLERK, ASSISTANT LIBRARIAN, AND CURATOR OF THE MUSEUM.—Edward Clibborn, Esq.

Professor Heinrich Ewald, of Göttingen, was elected an Honorary Member.

The President, under his hand and seal, appointed the following Vice-Presidents for the ensuing year:—

Henry Hennessy, F.R.S.
William Stokes, M.D., F.R.S.
Sir W. R. Wilde, M.D.
Samuel Ferguson, LL.D.

APRIL 11, 1870.

PROFESSOR HENNESSY, F.R.S., V.P., in the Chair.

Richard Joseph Cruise, Esq.;
Sir Arthur Guinness, Bart.;
John Vickers Heily, M.D.;
George Macartney, Esq.;
Thomas F. Pigott, Esq.;
Joseph Watkins, Esq., R.H.A.,

were elected Members of the Academy.

The following Papers were read:—

"On the Missing Book of Clonenagh." By the Rev. John O'Hanlon.

"On some Sepulchral Urns and Buried Monuments in the County of Tyrone." By George Sigerson, M.D.

"On the Morphology of Sexes in some Diœcious Plants." By David Moore, Ph.D.

APRIL 25, 1870.

PROFESSOR HENNESSY, F.R.S., V.P., in the Chair.

The following Papers were read:—

"On Mammalian Bones from the Zinc Deposits in the North of Spain."

"On the Chemical Composition of the Augite and Hornblende Groups of Minerals." By W. K. Sullivan, Ph. D.

MAY 9, 1870.

REV. J. H. JELLETT, B.D., President, in the Chair.

The following Paper was read :—

"On the Germ Theory, in Connexion with Putrefaction." By William Stokes, M.D., F.R.S.

MAY 23, 1870.

REV. J. H. JELLETT, B.D., President, in the Chair.

Abraham Fitzgibbon, Esq., C.E.;
Emanuel Hutchinson, Esq.;
John Kelly, Esq.,

were elected Members of the Academy.

The following Papers were read :—

"On the Propagation of Sensation along the Nerves." By Robert M'Donnell, M.D., F.R.S.

"On Coins and Seal presented." By W. H. Hardinge, Esq.

Donations were presented, and thanks voted to the Donors.

JUNE 13, 1870.

REV. J. H. JELLETT, B.D., President, in the Chair.

John P. Keane, Esq. C.E.;
Hugh Leonard, Esq.,

were elected Members of the Academy.

The following Paper was read :—

"Further Researches on the Atmosphere." By George Sigerson, M.D.

JUNE 27, 1870.

REV. J. H. JELLETT, B.D., President, in the Chair.

The following Papers were read :—

"On the Physical Formation of the Rain Basins of Ireland." By R. H. Frith, Esq., C.E.

"On the Capture of Ziphius Sowerbyi." By William Andrews, Esq.

"On the Evidence as to the Existence of the MS. called the Book of Clonenagh." By Mr. D. F. Dowling.

The Index to the "Proceedings," Vol. X., prepared by the Rev. W. Reeves, D.D., was presented; and

"The marked thanks of the Academy were given to the Rev. Dr. Reeves for his kindness in undertaking so great a labour."

The Academy then adjourned to November 14, 1870.

GENERAL ABSTRACT OF THE ACCOUNT

FROM 31st

RECEIPTS.

Heads of Account.	Receipts in Detail. £	s.	d.	Gross A[mount] of each
Special Receipts.				
Vote of Parliament for preparation of Scientific Reports,	200	0	0	
Vote of Parliament for a Museum Clerk and other objects in aid of the study of Antiquities,	200	0	0	
Vote of Parliament for a Library Clerk and for cost of Books and Binding,	200	0	0	
Vote of Parliament for Illustrating Transactions and Proceedings,	200	0	0	
Vote of Parliament for Salary of an Irish Scribe and for Cataloguing and Printing Irish Manuscripts,	200	0	0	
Vote of Parliament for Treasure Trove,	100	0	0	
Interest of the Cunningham Bequest and unappropriated Savings, funded in New 3 per cent. Stock (gross Stocks, £2245 11*s*. 0*d*.),	63	6	3	
Life Compositions for Annual Subscriptions funded in Consol Stock (gross Stock, £1934 3*s*. 3*d*.)	27	6	0	
Produce of Sales of Museum Catalogue, including balance of £1 19*s*. 8*d*. to its credit on 31st March, 1869,	12	12	3	
				1203
Receipts for General Purposes.				
Cash balance on 1st April, 1869,	18	17	8	
Vote of Parliament in aid of General Funds,	584	0	0	
Annual Subscriptions,	239	8	0	
Interest of Life Compositions, Consol Stock,	55	19	0	
Entrance Fees,	99	15	0	
Tea Fund,	11	9	0	
Proceedings sold in the Academy,	0	6	0	
Miscellaneous Receipts,	15	0	0	
				1024 14

This Account and Bank Balance reconciling Abstract, viz.:—

	£	s.	d.
Balance per Bank Certificate,	£399	11	9
Add, in Mr. Hodges' hands for Postage,	0	11	2
	400	8	11
Deduct, due Mr. Gibson on Incidental Account,	0	16	2
This account balance,	£399	12	9

£2227 19

I solemnly and sincerely declare that the above Account is just and true, according to correct.

Declared before me at D.

(Signed

☞ The Accounts from which this Abstract was taken w

TO 1st APRIL, 1870.

PAYMENTS.

Heads of Account.	Payments in Detail. £	s.	d.	Gross Amount of each Class. £	s.	d.
SPECIAL APPROPRIATIONS.						
For preparation of Scientific Reports,	200	0	0			
For Museum objects, as contra,	200	0	0			
For Library objects, as contra,	200	0	0			
For Illustrating Transactions and Proceedings,	126	1	3			
For Salary of Irish Scribe, &c., as per contra,	200	0	0			
Treasure Trove,	23	0	0			
Equivalent (£68 12*s.* 9*d.*) of 3 per cent. Stock, for Cash,	63	6	3			
Equivalent (£28 8*s.* 4*d.*) of Consol Stock, for Cash	27	6	0			
Equivalent (£5 0*s.* 4*d.*) of Bank of Ireland Stock, for Cash,	12	12	3			
				1052	5	9
GENERAL PURPOSES APPROPRIATIONS.						
In aid of Parliamentary Grants for objects connected with the study of Antiquities,	36	5	4			
In aid of Parliamentary Grant for cost of Books, Binding, &c.,	83	2	2			
In aid of Parliamentary Grant, Irish Scribe,	8	17	10			
Salaries,	336	7	6			
Wages and Liveries,	110	1	0			
Stationery,	14	17	1			
Miscellaneous Printing,	14	7	7			
Solicitor's Account,	7	2	2			
				611	0	8
CONTINGENCIES.						
Coals,	20	12	6			
Gas,	25	1	10			
Taxes and Insurance,	8	2	6			
Furniture and Repairs,	21	11	6			
Bank of Ireland, discounts on Cheques,	0	0	9			
Incidents, per Mr. Clibborn,	33	2	2			
Incidents, per Booksellers,	4	15	0			
Postage, per Mr. Hodges,	21	12	5			
Special Contingencies out of Surplus Fund,	20	0	0			
Tea Fund,	10	1	4			
				165	0	0
				1828	6	5
Balance to credit of Year's Account, 1870-1,				399	12	9
This Balance is apparent only, as there is a liability for Printing and Illustrating Papers in the Transactions and Proceedings ordered by the Committee of Publication of £250 0 0						
A liability for Lithographing Irish MSS. of . . 50 0 0						
The Treasure Trove articles deposited in the Museum, and offered for sale to the Academy, would need a far larger sum than the apparent saving on the Treasure Trove Grant of . . 77 0 0						
The real Balance amounts to 22 12 9						
	£399	12	9			
				£2227	19	2

knowledge and belief; and I make this solemn declaration conscientiously believing the same to be

W. H. HARDINGE, *Treasurer, R. I. A.*

is 20th day of April, 1870,

O'FERRALL.

May, 1870, by the Rev. M. H. Close, and William Archer, Esq.

APPENDIX.

MINUTES OF THE ACADEMY

FOR THE SESSION 1870-71.

November 14, 1870.

Rev. J. H. Jellett, B. D., President, in the Chair.

The following Paper was read:—

"On the difficulties attendant on the transcription of Ogham Legends, and the means of avoiding them." (Part 1st.) By Samuel Ferguson, LL. D. The author presented a collection of paper casts or moulds, taken from a number of Ogham-inscribed stones, illustrative of his paper, whereupon it was resolved,

"That the handsome present of impressions of Ogham monuments, offered by Dr. Ferguson, be gratefully accepted, and that the marked thanks of the Academy be given to him for his important gift."

The Secretary of Council brought up the proposed Memorial to Her Majesty's Government about the preservation of the scientific, literary, and artistic collections of Paris, which was read and adopted. (See p. xxv.)

Donations to the Museum were presented, and thanks voted to the several donors.

Stated Meeting, November 30, 1870.

Rev. J. H. Jellett, B. D., President, in the Chair.

The Right Hon. the Earl of Rosse, and the Right Hon. the Lord Ventry, were elected Members of the Academy.

A letter from the Right Hon. Earl Granville, in answer to the Memorial addressed to Her Majesty's Government, was read. (See p. xxvi.)

The President delivered an address.

It was proposed by Sir Robert Kane, M. D., &c., seconded by William Stokes, M. D., &c., and resolved unanimously:—

"That the President's Address be printed in the 'Proceedings.'"

The following recommendation of the Council was adopted:—

"To recommend the Academy to allocate the sum of £50 to G. J. Stoney, Esq., in aid of his researches on the refractive index of air for each wave length.

DECEMBER 12, 1870.

Rev. J. H. JELLETT, B. D., President, in the Chair.

Robert D. Joyce, M. D., Boston, U. S., was elected a Member of the Academy.

The following Papers were read:—

"On the difficulties attendant on the transcription of Ogham Legends, and the means of avoiding them." (Part 2nd.) By Samuel Ferguson, LL. D.

"On some new or little-known freshwater Rhizopods." By William Archer, Esq.

JANUARY 9, 1871.

Rev. J. H. JELLETT, B. D., President, in the Chair.

Very Rev. Ulick J. Bourke, George Woods Maunsell, Esq., John Symons, Esq., Ramsay H. Traquair, M. D., were elected Members of the Academy.

The following Papers were read:—

"Laboratory Notes."

No. 1. "On the formation of Acetic acid by the destructive distillation of Resin." No. 2. "On the production of Ozone by Resin oils." By Charles R. C. Tichborne, F. C. S.

"On the Cause of the interrupted Spectra of Gases. By G. J. Stoney, F. R. S.

"On existing National Monuments in the County of Kerry." By Henry Stokes, C. S.

The Secretary read the letters received from learned bodies, in reply to his note, enclosing copies of Memorial to Her Majesty's Government (see p. xxvi.), addressed to them.

These letters will be found in the "Correspondence relative to the Bombardment of Paris," p. xxv., *et seq.*

A letter was also read from Mons. George Livio, Consul of France, in Dublin. This letter will be found in the Correspondence just referred to.

The proposed estimate of income and expenditure for the year 1870-71, adopted by the Council, was laid before the Academy.

JANUARY 23, 1871.

HENRY HENNESSY, F. R. S., Vice-President, in the Chair.

The following Papers were read:—

"Account of Experiments on the resistance of the air to the Motion of Vortex Rings." By Robert S. Ball, M. A.

"Additional Observations on Muscular Anomalies in Human Anatomy (third series), with a catalogue of the Principal Muscular Variations." By Alexander Macalister, M. D.

"On an Ogham stone at Kilbonane, County Kerry." By R. R. Brash, Esq.

"On an Ancient Bronze Instrument found near Tara." By Alexander G. More, F. L. S.

The following Recommendation of Council was brought up and unanimously adopted:—

"That chap. v., section 6. *e*, as follows:

"'The names of such Members as shall be found to have attended less than ten meetings of the Council (including *stated* meetings of any one Committee of Council during the year, before the meeting at which the lists are prepared, and exclusive of that meeting (at which they shall have no seat), shall be omitted in the preparation of the list of forty-three names required by the Charter, and shall not be included in the Council of the preceding year, but shall be treated as if such members had died or resigned,—provided that if any Member of Council shall have been elected in the middle of the year, he shall not be required to attend ten meetings in order to retain his place in the list, but only such a proportion of the whole number of meetings since his election as the Council shall judge to be equivalent to ten out of the whole number.

"'The Committees intended by the foregoing resolution are the Committees of Science, Polite Literature, Antiquities, Publication, Economy, and Library:'

be altered by the omission of the last clause, and that the word 'permanent' be inserted in the first sentence of same paragraph, before the words 'Committee of Council.'"

FEBRUARY 13, 1871.

Rev. J. H. JELLETT, B. D., President, in the Chair.

Rev. P. Shuldham Henry, D. D., Henry Dix Hutton, LL.B., and J. W. Ellison Macartney, Esq., were elected Members of the Academy.

The following Papers were read :—

"On the Difficulties attendant on the Transcription of Ogham Legends, and the means of avoiding them. (Part 3rd.) By Samuel Ferguson, LL.D.

"On Results obtained by the Agosta Expedition to observe the recent Solar Eclipse." By Charles E. Burton, Esq.

"On the Geological and Microscopic Structure of the Serpentine Marble or Ophite of Skye." By Professors W. King and T. H. Rowney.

"On Eozoon Canadense." By Principal Dawson, of Montreal.

Donations were presented, and thanks voted to the several donors.

CORRESPONDENCE RELATIVE TO THE BOMBARDMENT OF PARIS.

Copy of Memorial to Her Majesty's Government, adopted by the Royal Irish Academy, at their General Meeting, held on Monday, November 14th, 1870.

To the Right Hon. Earl Granville, K. G.,

Her Majesty's Principal Secretary of State for Foreign Affairs.

We, the President and Members of the Royal Irish Academy, desire to call the earnest attention of Her Majesty's Government to the irreparable loss which would be sustained by the whole civilized world if the inestimable scientific, literary, and other collections of Paris should be destroyed or seriously injured during the siege. That city contains galleries stored with treasures of art, libraries rich in every species of literary monument, and scientific museums which are amongst the foremost in their several kinds. These collections represent the accumulated labours of many generations, and are, in truth, the property not of France only but of the whole civilized world. Many of the objects contained in them, if once allowed to perish, no subsequent exertion could ever replace. The fate of the Library at Strasburg shows that these priceless collections are in real and imminent peril from the operations of the war. It is not for us to pronounce any opinion on the merits of the present lamentable struggle, or on the conduct of either of the contending parties; but, as members of a body, having for its object the cultivation of Science, Literature, and Archæology, we protest, in the name of the intellectual interests of humanity, against the destruction of these collections; and we respectfully call upon Her Majesty's Government to use their utmost efforts for their preservation, by impressing on the belligerents the duty of taking every possible precaution for their protection from the dangers to which they are likely to be exposed.

ANSWER OF EARL GRANVILLE.

"FOREIGN OFFICE, *November 24th*, 1870.

"SIR—I am directed by Earl Granville to acknowledge the receipt of the Memorial of the Royal Irish Academy of the 14th instant, requesting that Her Majesty's Government will use their influence, in order to induce the belligerent Powers to take every possible precaution to secure from the destruction with which they are threatened the scientific, literary, and artistic collections now existing in Paris; and I am to inform you in reply, that Lord Granville has caused a copy of your Memorial to be transmitted to Her Majesty's Ambassador at Berlin for communication to the Prussian Government.

"I am, Sir,
"Your most obedient
"Humble Servant,
"E. HAMMOND.

"*The President of the Royal Irish Academy,*
"19, *Dawson-street, Dublin.*"

Copy of Note of the Secretary of the Royal Irish Academy, addressed, with a copy of the above Memorial, to different Learned Societies and Universities of Europe.

"ROYAL IRISH ACADEMY, DUBLIN,
"16 *November*, 1870.

"SIR—I am directed by the Royal Irish Academy to forward to you the enclosed copy of a Memorial to Her [Britannic] Majesty's Government, and to solicit the co-operation of your Society [University] in the object of it.

"Yours faithfully,
"W. K. SULLIVAN,
"*Secretary of the Academy.*"

ANSWERS RECEIVED FROM UNIVERSITIES.

University of Oxford.

"*Christ Church, Oxford, November 22nd*, 1870.

"SIR—I have taken the earliest opportunity of laying your letter, with its enclosure, before the Council of the University.

"I am directed to say that we sympathise most heartily in the anxious wish of the Royal Irish Academy that the costly Works of Art and the Literary and Scientific Collections of Paris, should be protected from danger in the terrible event of a bombardment.

"At the same time, it is not very easy—according to the forms of the University—to express any general opinion upon the subject; and the Council deem it the less necessary, because they are assured, on what seems to them excellent authority, that the present Government of Defence has taken care that all precious works of the kind alluded to have been deposited in bomb-proof vaults.

"Still the Royal Irish Academy may rest assured that whatever influence the University of Oxford can exert shall be used in so good a cause.

"I have the honour to be, Sir,
"Your obedient Servant,
"H. G. LIDDELL,
"*Vice-Chancellor.*

"*To the Secretary of the Royal Irish Academy.*"

University of Bonn.

"BONN, 19, *Nov.*, 1870.

"Euer wohlgeboren für mich höchst befremdende Aufförderung, an Schritten bei der englischen Regierung zum Schütz der pariser wissenschaftlichen Sammlungen vor Kriegsgefahr theilzunehmen, habe ich empfangen. Ich sehe mich durchaus nicht in der Lage Ihren Wünsche zu entsprechen, und kann dies um so weniger bedauern als für jeder unbefangen hinlänglich gewiss ist, dass die deutsche Kriegsleitung, auch ohne fremde Ermahnung, fest gesonnen ist, Schätze der Wissenschaft und der Kunst, so viel an ihr liegt, nicht der Zerstörung Preis zu geben.

"Der Königliche Oberbibliothecar,
"JACOB BERNAYS.

"*Herrn W. K. Sullivan, wohlgeboren, Dublin.*"

[Translation.]

"BONN, 19 *Nov.*, 1870.

"SIR,—I have received, for me a very strange summons, to take part with the English Government in steps for the protection of the Parisian Scientific Collections against the danger of war. I do not see myself by any means in a position to correspond to your wishes, and I can regret this the less, as it is sufficiently apparent to every unprejudiced person, that the German leaders of the war are fully determined, as far as in them lies, not to give up to destruction treasures of Science and Art.

"The Royal Principal Librarian,
"JACOB BERNAYS.

"*W. K. Sullivan, Esq., Dublin.*"

The University of Göttingen.

"GÖTTINGEN, *den* 14 *Decembre*, 1870.

"SEHR GEEHRTER HERR SECRETÄR DER ROYAL IRISH ACADEMY,

"In Ihrer geehrten Zuschrift v. 17 v. M. beanspruchen Sie im Auftrage der Royal Irish Academy die Mitwirkung unserer Universität für Schritte, durch welche die Regierung Ihrer Grossbritannischen Majestät bewogen werden soll, gegen die den wissenschaftlichen und Kunstschätzen von Paris durch die militärischen operationen drohende Gefahr der Vernichtung Einspruch zu erheben, und sich dabei auf den einstimmigen Protest der gelehrten Institute der gebildeten Welt zu stützen. Die Royal Irish Academy begleitet diese Zumuthung mit der Versicherung, dass sie dem gegenwärtigen Kampfe Deutschlands und Frankreichs mit voller Unparteilichkeit gegenüberstehe. Zunächst dieser Behauptung muss ich im Namen der gelehrten Körperschaft, welcher ich vorzustehen die Ehre habe, widersprechen, Es hätte der R. Irish Academy sonst nicht entgehen können, dass jene Gefahren die Folge sind der Befestigung von Paris, für welche sich der Ehrgeiz unserer ruhelosen Nachbarn durch den gefeiertsten historischen Romanschreiber Frankreichs, durch Thiers, gewinnen liess, damit dies Land in Zukunft vor den Folgen des etwaigen Missglückens seiner periodisch wiederkehrenden Angriffe auf den Frieden Europas bewahrt bleibe. Damals als Frankreich die Stätte, welche so viele Schätze der Bildung,—"ein Besitzthum der ganzen Menschheit," wie Sie bemerken,—umschliesst, in die grösste Festung der Erde umzuwandeln bechloss, wäre es vielleicht angezeigt gewesen, wenn die gelehrten Körperschaften Englands sich an die spitze eines Protestes der gelehrten Welt gegen dies culturfeindliche Unternehmen gestellt hätten. Es ist indessen so wenig damals von einem Proteste der Wissenschaft zu Gunsten von Paris etwas zu hören gewesen, wie sich die Stimme der Royal Irish Academy erhoben hat, als Rom,—welches doch nicht minder werthvolle unersetzliche Schätze der gelehrten Bildung und Kunst in sich schliesst, wie Paris,—1849 von den Franzosen unter Oudinot, oder im laufenden Jahre von den italienischen Truppen mit Waffengewalt genommen wurde. Ja selbst als die eigenen Truppen Ihrer Grossbritannischen Majestät die aufstandischen Sepahis, deren Kriegführung derjenigen der heutigen französischen Republicaner so überraschend ähnlich sah, in Delhi belagerten, hat sich in England kein Protest vernehmen lassen, um die an Monumenten alter Cultur reiche Stadt vor dem englischen Belagerungsgeschütze zu bewahren. Was aber Paris betrifft, so hat die deutsche Heeresleitung bereits bethätigt, dass sie bei der Belagerung jede Schonung übt, welche mit der unerbittlichen Pflicht vereinbar ist, den Deutschland aufgedrungenen Kampf zum Ziele zu führen. Wenigstens den gelehrten Körperschaften Englands würde es daher anstehen, mit Dank es

aufzunehmen, dass diese Kriegführung das Bombardement der belagerten Festung bisher hinausgeschoben hat, statt in ihre Regierung zu dringen, diese Heeresleitung mit neuen Zudringlichkeiten zu belästigen. Alle diese nahe liegenden Erwägungen haben jedoch die Royal Irish Academy von dem Versuche nicht abgehalten, die gelehrte Welt Namens der Humanität und Civilisation gegen die Belagerer von Paris in die Schranken zu rufen, während doch nur wenig Unbefangenheit dazu gehörte, um zu erkennen, dass bei Paris die Humanität und die Civilisation im Lager der Belagerer zu finden sind. Diese gelehrte Körperschaft hat aber zugleich keinen Anstand genommen, einer deutschen Universität das Ansinnen zu stellen, sich an ihrem Unternehmen zu betheiligen. So kann ihr denn auch die Antwort nicht erspart werden, dass nach unserer deutschen Auffassung, welche die des gesunden Menschenverstandes ist, Derjenige, welcher der strafenden Gerechtigkeit in den Arm fällen will, sich selbst an dem Verbrechen betheiligt. Das deutsche Volk das in seinem geistigen Ringen noch immer das stolze Wort des Paracelsus wahr zu machen sucht: "Engländer, Franzosen, Italiener, ihr mir nach, ich nicht euch," hat die Arbeit friedlicher Gesittung, das einzige Feld seines Ehrgeizes verlassen müssen, weil durch einen frevelhaften Raubanfall seine höchsten Güter, sein nationales Dasein, seine sittliche Selbstbestimmung, seine Ehre bedroht wurden, es kämpft heute in Frankreich für die künftige Sicherstellung dieses heiligen Besitzthums, zugleich aber auch für den Frieden der Welt und für die Gesittung der Menschheit. Denn diese wäre dem Untergange verfallen, wenn der Gedanke vergeltender Gerechtigkeit aus dem Bewusstsein der Völker verschwinden könnte. Dass der Welt der Glaube an diese Gerechtigkeit unverloren bleibt, das dankt sie nächst Gottes Gnade dem deutschen Volke. Als Europa den sittlichen Muth nicht fand, frevelhaftem Friedensbruch zu wehren, da hat dies Volk, gerechten Gerichtes in den Donnern der Schlachten harrend, sein Dasein in die Schanze geschlagen, da hat es die geistige Blüthe seiner Jugend hinausgesandt in den heiligen Kampf, den ein grosser englischer Geschichtschreiber mit Recht gezeichnet hat als den Kampf der Engel wider Belial. Auch unsere Hochschule, die ihre ganze Ehre darin findet, deutsch zu sein, hat Hunderte von deutschen Jünglingen unter die Waffen gestellt, die Ungleichheit des Einsatzes nicht achtend, wo wir gezwungen sind, gegen africanisch Halbwilde oder gegen das zusammengelaufene Gesindel Garibaldischer Abenteurer zu kämpfen. Die deutsche Wissenschaft betrauert bereits unter den gefallenen Helden einige ausgezeichnete Gelehrte hoffnungsreiche Jünglinge in grosser Zahl. England aber möge uns mit Einmischung jeder Art vom Leibe bleiben. Möge dem britischen Volke bald wieder vergönnt sein, in die Bahnen seiner grossen Vergangenheit einzulenken, wo in jedem welterschütternden Kampfe für die wahren Interessen der Menschheit, für die Gerechtigkeit, für den Frieden und die Freiheit Europas auch das britische Schwert in die Wagschale gelegt wurde. Die gelehrten Körperschaften England's aber werden der Humanität den besten Dienst leisten, wenn sie mit

ihrem Ansehen in die Schranken treten gegen die Verletzung des Wesens der Neutralität durch die von der gegenwärtigen Grossbritannischen Regierung adoptirte Behandlung des Waffenhandels, gegen die den heutigen Machthabern Frankreichs zur Last fallende Untergrabung der Grundlagen des Völkerrechts, und für eine Fortbildung des letztern im Sinne der Gerechtigkeit und Gesittung (Unverletzlichkeit des Privateigenthums zur See u. s. w.). In solchen Bestrebungen dürfen dieselben der eifrigen Unterstützung der deutschen Wissenschaft gewiss sein.

"Ich habe die Ehre ganz ergebenst zu zeichnen,

"Dr. Richard Dove,

"*Z. Z. Prorector der Georg-Augusts-Universität zu Göttingen.*"

[Translation.]

"Göttingen, 14*th December*, 1870.

"Very Honoured Mr. Secretary of the Royal Irish Academy,

"In your esteemed communication of the 17th ult., you invite, in the name of the Royal Irish Academy, the co-operation of our University in certain steps by which the Government of Her Britannic Majesty may be induced to protest against the threatened destruction of the scientific and artistic treasures of Paris through military operations, and thereby support itself upon the unanimous protest of the learned societies of the civilised world. The Royal Irish Academy accompanies this request with the assurance that it regards the contest between Germany and France with entire impartiality. To this position I must, in the name of the learned body which I have the honour to represent, demur. It can hardly have escaped the notice of the Royal Irish Academy that these perils are the consequence of the fortification of Paris, for which the ambition of our restless neighbours is indebted to the most distinguished historical romance writer of France, Thiers, in order that the country might in future be secure against the possible miscarriage of its periodical recurring attacks on the peace of Europe. At the time when France decided on transforming the place which encloses so many treasures of culture—the 'property of the entire human family,' as you observe—into the greatest fortress of the world, it might have been becoming for the learned bodies of England to have headed a protest of the learned world against this undertaking so hostile to culture. But neither was then a protest of science heard of, nor did the Royal Irish Academy raise its voice when Rome—which contains treasures not less precious and unique than those of Paris—was taken by force of arms in 1849, by the French under Oudinot; and by the Italian troops during the present year. Nay, when the troops of Her Britannic Majesty besieged in Delhi the revolted Sepoys, whose method of conducting warfare was so surprisingly

similar to that of the present French Republicans, no voice was raised in England for the preservation of a city, so rich in monuments of ancient culture, from the English besieging fire. With regard to Paris, however, the German military commanders have already shown that they will exercise every forbearance compatible with their inexorable duty of carrying to a successful issue the war forced upon Germany. It would better become the learned bodies of England thankfully to acknowledge that the military authorities have thus far delayed the bombardment, than to urge their Government to harass them by fresh importunities. All these obvious considerations, however, have not restrained the Royal Irish Academy from summoning the whole world, in the name of humanity and civilization, into the lists against the besiegers of Paris; whilst only a little impartiality is required in order to recognise that at Paris it is in the camp of the besiegers that humanity and civilization can be found. This learned body has at the same time not hesitated to ask the participation of a German University in its project. They cannot, therefore, expect to escape the retort, that according to our German perception, which is that of sound human reason, those who strive to arrest the arm of retributive justice become themselves sharers in the crime. The German people, which, in its intellectual strivings, has ever sought to justify the proud words of Paracelsus: 'English, French, Italians! you after me, not I after you,' has been forced to leave the labour of peaceful civilization, the only field of its ambition, because its noblest possessions, its national existence, its moral independence, its honour, were threatened by a burglarious attack. It is now fighting in France for the future security of these sacred possessions, and at the same time for the peace of the world, and the civilization of mankind. For these must all perish if the idea of retributive justice should fade out of the conscience of nations. That faith in this justice has not perished from the world is due, under God, to the German people. When Europe had not the moral courage to resist a scandalous breach of the peace, this nation, awaiting a righteous judgment amid the thunder of the battle, threw its very existence into the arena; it sent forth the intellectual blossoms of its youth into the holy war, which a great English historical writer has rightly characterised as a fight of the Angels against Belial. Our high school, whose greatest boast it is that it is German, has likewise sent to the field hundreds of German youths, heedless of the disparity of the game in which we are compelled to fight against African half-savages, or the rabble of Garibaldian adventurers. German science already mourns among the fallen heroes several distinguished scholars, promising youths in large numbers. Let England, then, keep aloof from intervention of any kind! May it be soon again granted to the British people to return to the path of their great past, when in every world-shaking struggle the British sword was also thrown into the scale for the true interests of humanity, for justice, for peace, and for the liberty of Europe! But the learned bodies of Britain would best serve humanity by stepping with

their prestige into the lists against the violation of the essence of neutrality by the conduct of the present British Government respecting the trade in arms; against the sapping, by the present rulers of France, of the principle of international law, and for the further development of the latter in the direction of justice and civilization—inviolability of private property at sea, &c., &c. In such endeavours they may rely on the zealous support of German science.—I have the honour to be, very respectfully yours,

"DR. RICHARD DOVE,
"*Pro-Rector (pro tem.) of the Georg-August*
"*University of Göttingen.*"

The University of Halle.

"*Rector et Senatus Universitatis Halensis cum Vitebergensi consociatae*
"*Academiae Regiae Hiberniae sodalibus.*

"*S. D.*

"In schedulis, quas nuper etiam ad nos misistis, nescimus quid magis miremur, utrum eorum, quae a nobis petivistis inauditam audaciam an singularem vestram, quam Goettingenses jam satis lucide vobis exposuerunt, in judicandis rebus nostris levitatem atque ignorantiam. Quam quin in excolendis litteris procul semper a vobis habeatis non dubitamus.

"Dabamus Halae d. XXIII m. Dec. a. MDCCLXX. [*sic.*]

"H. KNOBLAUCH."

ANSWERS RECEIVED FROM LEARNED SOCIETIES.

From the Imperial Leopold-Caroline German Academy of Naturalists.

"DRESDEN, *den* 24 *November*, 1870.

"Die Kaiserlich Leopoldinisch-Carolinisch-Deutsche Akademie der Naturforscher bedauert, nicht in der Lage zu sein, der Royal Irish Academy die Mitwirkung zu gewähren, zu der sie durch das Schreiben des geehrten Secretärs der Königlichen Academie vom 17 d. M. aufgefordert wird.

"Würde dieselbe auch mit nicht geringerem Schmerze als die Royal Irish Academy es betrauern, wenn durch die Belagerung von Paris unersetzliche Theile der reichen wissenschaftlichen Schätze dieser Stadt zerstört werden sollten, wie diess leider bei der Belagerung von Strassburg der Fall gewesen ist, so kann sie sich doch, da sie eine Deutsche Akademie ist, nicht auf den Standpunkt der Königlichen Academie stellen, welche sich nicht berechtigt hält, eine Meinung über das Verschulden dieses bedauerlichen Kampfes und das Verfahren der beiden streitenden Theile zu aeussern.

"Dass die Stimme der Akademie der Naturforscher auf die gegenwärtigen Machthaber in Frankreich irgend einen Einfluss ausüben werde, kann sie leider nicht erwarten und sie darf nicht gegen Maassregeln protestiren, die die Sicherheit, die Unabhängigkeit und der Friede Deutschlands dringend erheischen möchten, und die ihr Vaterland durch das Opfer vieler Tausende seiner Söhne zu erkämpfen im Begriff steht.

"Sollte sich dieses Ziel erreichen lassen, ohne jene Sammlungen in Gefahr zu bringen, so ist sie überzeugt, dass die Führer der Deutschen Heere, die vollkommen den Werth jener in Paris aufgehäuften Schätze kennen, und z. B. in St. Cloud und Sevres gezeigt haben, wie sehr sie bemüht sind, culturhistorische Sammlungen selbst vor der Zerstörung durch die eigenen Besitzer zu retten, sie nicht in Gefahr bringen werden und es würde ein unbegründetes und verletzendes Misstrauen beweisen darum zu bitten.

"Eine ernstliche Gefahr von Seiten der Deutschen Heere würde jenen Sammlungen übrigens nur durch ein Bombardement von Paris erwachsen.

"So lange ein solches Verfahren von allen Nationen als ein berechtigtes Kriegsmittel angesehn wird, obgleich es Schuldige und Unschuldige, Wehrhafte und Wehrlose in gleichem Maasse gefährdet, kann ein Kriegführender es nicht einseitig aufgeben, ohne die ihm anvertrauten höchsten Interessen seines Vaterlands zu verletzen.

"Sollte indess die Königliche Akademie sich von dem Versuche Erfolg versprechen, dieses und ähnliche aus einer anders fühlenden Vorzeit stammende Mittel der Kriegsführung, wie das Erbeuten des Privateigenthums auf dem Meere und den Handel der Neutralen mit Waffen und anderer Kriegscontrebande an die Kriegführenden ganz allgemein abzuschaffen und durch das Völkerrecht verwerfen zu lassen, wie dies mit den explodirenden Geschossen des Kleingewehrs geschehen ist, so würde die Deutsche Akademie der Naturforscher sehr bereit sein, so weit an ihr liegt, diesen wichtigen Fortschritt zu unterstützen.

"*Der Präsident der Kaiserlich Leopoldinish-Carolinish Deutschen Akademie der Naturforscher,*

"Dr. J. BEHN.

"*An die, Royal Irish Academy, Dublin.*"

[Translation.]

"DRESDEN, *the 24th November*, 1870.

"The Imperial Leopold-Caroline German Academy of Naturalists regrets not to be in a position to grant the Royal Irish Academy the co-operation to which they were invited by the letter of the honourable Secretary of the 17th of this month.

"The Imperial Leopold-Caroline German Academy would also regret with no less sorrow than the Royal Irish Academy if portions of the rich scientific treasures of Paris, which could not be replaced, were to be destroyed by the bombardment of that city, as was unfortunately the case at the bombardment of Strasbourg. Still, as it is a German Academy, it cannot place itself on the stand-point of the Royal Irish Academy, which does not feel itself justified in expressing an opinion on the merits of this pitiful war, and the proceedings of both the contending parties.

"That the voice of the Academy of Naturalists would have any influence whatever with the present holders of power in France cannot unfortunately be expected; and it dare not protest against measures which the safety, the independence, and the peace of Germany might urgently demand, and what its Fatherland, by the sacrifice of many thousands of her sons, is in the act of conquering.

"Should this end be attained without endangering those collections, we are persuaded that the leaders of the Germans, who well know the value of those accumulated treasures in Paris, and have shown, for example, in St. Cloud and Sevres, how very anxious they are to preserve collections illustrative of the history of civilization even from destruction by their own owners, and who will not bring them into danger. It would, therefore, show an unfounded and offensive mistrust to make such a demand. Besides, a serious danger to these collections on the part of the German army would arise only from the bombardment of Paris.

"As long as such a proceeding is looked on by all nations as a justifiable method of warfare, although it endangers alike the guilty and the innocent, the armed and unarmed, a belligerent cannot relinquish it on his side alone without violating the highest interests of his Fatherland confided to him.

"Should the Royal Irish Academy, however, promise themselves success from this trial in generally abolishing, and by the law of nations doing away with those and similar means of carrying on war, which date from a differently thinking past—such as the robbery of private property on the sea the trade of neutrals with belligerents in arms, and other contraband of war, as was done with exploding balls for small arms—the German Academy would, in such a case, be quite ready to support, as far as it could, such an important step in advance.

"*The President of the Leopold-Caroline German*
"*Academy of Naturalists,*

"Dr. Behn."

The Society of the Natural Sciences of the Canton of Vaud.

"*A Monsieur* W. K. SULLIVAN, *Secrétaire de Royal Irish Academy à Dublin.*

"MONSIEUR—La Société Vaudoise des Sciences Naturelles partage avec l'Académie Royal d'Irlande, le désir de voir préservées des éffets désastreux de la guerre, les Collections Scientifiques, Artistiques, et Litteraires de Paris. Quoique nous soyons bien èloignes de penser que l'armee assiégeante ait l'intention de détruire des Collections qui sont pour ainsi dire le bien commun de tout le monde civilisé, nous serions heureux de voir couronneé de succés la démarche faite auprès de Gouvernement Britannique par l'Académie Royal d'Irlande.

"Au nom de la Société Vaudoise de Sciences Naturelles.

"*Le Président,*
"J. B SCHUETZLER, *Prof.*

"*Le Secrétaire,*
"W. KRAISSE, *Ingenieur.*

"LAUNSANE, 24*th Novembre,* 1870."

[Translation.]

"*To* MR. W. K. SULLIVAN, *Secretary of the Royal Irish Academy.*

"LAUSANNE, 24 *November,* 1870.

"SIR—The Society of Natural Sciences of the Canton of Vaud shares with the Royal Irish Academy the desire to see the scientific, artistic, and literary collections of Paris preserved from the disastrous effects of the war. Although we are far from thinking that the besieging army has the intention to destroy those collections, which are, so to say, the common property of the whole civilized world, we shall be happy to see the memorial of the Royal Irish Academy to the British government crowned with success.

"In the name of the Society of Natural Sciences of the Canton of Vaud.

"*The President,*
"W. SCHUETZLER, *Prof.*

"*The Secretary,*
"W. KRAISSE, *Ingenieur.*"

The Geological Society of London.

Geological Society, Somerset House, W. C.
"*24th November*, 1870.

"SIR,—Your note of the 16th inst., with its accompanying memorial to Lord Granville, was yesterday laid before the Council of this Society.

"I am directed to inform you that, while fully sympathizing with the objects of the memorial of the Royal Irish Academy, the Council of the Geological Society thinks it needless again to call Earl Granville's attention to the irreparable loss to science that might result from the threatened bombardment of Paris.

"I remain, Sir,
"Yours faithfully,
"W. S. DALLAS,
"*Assistant Secretary Geological Society.*

"*W. K. Sullivan Esq.*"

The Imperial Society of Naturalists of Moscow.

"Société Imperiale des Naturalistes de Moscou.
"Moscou, *le* $\frac{14}{26}$ *Novembre*, '70.

"MONSIEUR—J'ai eu l'honneur de recevoir votre lettre du 17 Novembre avec la copie de la protestation de votre Academie Royale adressée à votre Gouvernement par rapport à la conservation des collections litéraires, scientifiques et artistiques en France. Je ne manquerai pas de la présenter à la Société Impériale dans sa premiére séance du $\frac{\text{19 Novembre}}{\text{1 Decembre}}$. Soyez assuré, Monsieur et cher Confrere, qu'ici à Moscou on a pensé et on pense journellement à cette malheureuse guerre qui a dejá détruit et qui détruira peut-être encore bien de collections et de travaux des siécles qui ne sont plus à remplacer ?

"Agrées, je vous prie, Monsieur, l'expression de la haute considération avec laquelle j'ai l'honneur d'être.

"Monsieur, votre tout devoué serviteur,
"DR. RENARD,
"*Secrétaire de la Soc. Imp. de Natur,*
"*Conseiller d'Etat actuel,*
"*Commandeur, &c.*"

[Translation.]

"Moscow, $\frac{14}{26}$ *November*, 1870.

"SIR—I had the honour to receive your letter of the 17th November, together with the copy of the protest of your Royal Academy addressed to your government in reference to the preservation of the literary, scientific, and artistic collections of France.

"I shall not fail to present it to the Imperial Society at its first meeting on $\frac{\text{19 November}}{\text{1 December}}$. Be assured, Sir, and dear colleague, that here in Moscow we think, and we daily think on this miserable war, which has already destroyed, and which probably will yet destroy, many collections, and the works of centuries, which cannot be again replaced.

"Accept, I beg of you, Sir, the expression of the high consideration with which I have the honour to be

"Sir, your very devoted servant,

"Dr. Renard,

"*Secretary of Imp. Soc. of Nat., Councillor of* "*State, Commander, &c.*"

The Royal Bohemian Society of Science, Prague.

"Prague, 27*th Nov.*, 1870.

"Sir—I have been directed by the Royal Bohemian Society of Sciences, to acknowledge the receipt of your letter of the 17th November, and of the copy of memorial to Her Majesty's Government, concerning the collections of Art and Science exposed to danger during the siege of Paris. Led by the same feelings and motives, the Royal Bohemian Society of Science had already, on the 6th November, addressed a memorial to the Imperial Austrian Government, a copy of which I beg to forward enclosed to the Royal Irish Academy.

"Yours faithfully,

"Dr. Joh. Er. Wocel,

"*General Secretary of the Society.*"

"*Copie des mit Sitzungsbeschluss vom* 2. *November* 1870 *von der kön. böhmischen Gesellchaft der Wissenchaften an den kais. österr Staatsminister Se. Exc. Grafen Potocki eingereichten Bittgesuches.*

"Euere Excellenz!—Frankreichs Haupstadt wird gegenwärtig von Gefahren bedroht, deren Folgen die ganze gebildete Welt auf das schmerzlichste empfinden würde. Paris birgt in seinem Schoosse Institute, Bibliotheken und Kunstsammlungen von unschätzbarem Werthe, welche seit Jahrhunderten den Gebildeten aller Nationen reichhaltige Quellen der wissenschaftlichen und Kunstforschungen darbieten. Der Nachtheil, den durch die Zerstörung jener Schätze die europäische Kultur und insbesondere die Wissenschaft in dem Falle erleiden würde, wenn Paris bombardirt werden sollte, wäre unabsehbar, und der Schrei des Entsetzens über die Vernichtung der Bibliotheken, Archive und Kunstsammlungen der Metropole Frankreichs würde niemals verstummen, sondern forttönen mit dem Fortschreiten der Jahrhunderte und zugleich als Echo die gerechte Klage hervor-

rufen, dass unsere Gegenwart nicht alle möglichen Mittel angewendet, um solch' eine Katastrophe abzuwenden.

"Die ergebenst gefertigte Gesellschaft der Wissenschaften glaubt, es sei insbesondere die Pflicht jener Korporationen, welche die Förderung der Wissenschaft zu ihrer Aufgabe gemacht, ihre Stimme gegen ein Verfahren zu erheben, welches vor dem Forum der Civilisation auf ewig verurtheilt und gebrandmarkt werden müsste. Die königl. böhm. Gesellschaft der Wissenschaften fühlt sich insbesondere gedrungen darauf hinzuweisen, das sich in den öffentlichen Bibliotheken und Archiven der Stadt Paris wichtige Denkmale der böhmischen Literatur und viele auf Böhmens Geschichte sich beziehende Handschriften befinden, die als Unica einen unschätzbaren Werth für das Königreich Böhmen haben, deren Vernichtung daher ein unersetzlicher Verlust für unser Land und Volk sein würde. Obgleich die ergebenst gefertigte Gesellschaft überzeugt ist, dass das edle, humane Gefühl Euerer Excellenz eines äusseren Impulses nicht bedarf, um das Möglichste zur Rettung der vom Verderben bedrohten literarischen und Kunstschätze in der belagerten Haupstadt Frankreichs zu versuchen, so glaubt sie doch eine vom wissenschaftlichen und Humanitätsinteresse streng gebotene Pflicht zu erfüllen, indem sie sich anschliesst an die von Sr. Durchl. dem Herrn Kurator des Ossoliński'schen Institutes an Euere Excellenze in dieser Richtung vorgelegte Bitte: dass die hohe k. k. Regierung im Vereine mit den übrigen neutralen Mächten mit Berufung auf die Genfer Konvention die zweckdienlichen diplomatischen Schritte einleiten möge, um die verderbendrohende Katastrophe von den wissenschaftlichen and Kunstanstalten der Metropole Frankreichs abzuwenden.

"Im Namen der königl. böhm. Gesellschaft der Wissenschaften:

"Dr. Franz Palacky, *Präsident.*
"Dr. Joh. Er. Wocel, *General-Sekretär.*

"Prag, 6 *November*, 1870."

[Translation.]

"*Copy of the Petition of the Royal Bohemian Society of Sciences to the Imperial Austrian Minister of State, His Excellency Count Potocki, agreed to at the meeting of 2nd November*, 1870.

"The capital of France is at present threatened with dangers, the results of which the whole civilized world would feel in the most painful manner. Paris shelters in its bosom institutions, libraries, and collections of works of Art of inestimable value, which have furnished for centuries abundant sources of Scientific and Art-investigations to the cultivated of all nations. The injury which European culture, and particularly Science, would suffer if Paris were to be bombarded,

would be immeasurable, and the cry of horror at the destruction of libraries, archives, and collections of works of Art in the metropolis of France would never become silent, but would sound onwards with the advance of centuries, and at the same time would call forth as an echo the just complaint that our time did not employ all possible means to avert such a catastrophe.

"The Society of Sciences believes it to be especially the duty of such corporations as have made the advancement of science their object, to raise their voice against a proceeding which must be for ever condemned and branded before the forum of civilization. The Royal Bohemian Society of Science feels itself particularly obliged to point out that important monuments of Bohemian literature, and many manuscripts relating to the history of Bohemia, are contained in the public libraries and archives of the city of Paris, which as unique documents have an inestimable value for the kingdom of Bohemia, the destruction of which on that account would be an irreparable loss for our country and people. Although the Society is persuaded that the noble, humane feelings of your Excellency do not require an external impulse to do your utmost for the rescue of the literary and art treasures threatened with destruction in the besieged capital of France, still the Society believe that it fulfils a duty, strictly enjoined upon it in the interest of science and humanity, in associating itself with the petition having this object in view, laid before your Excellency by his highness the Curator of the Ossolinski Institute:—That the Imperial Royal Government, in union with the other neutral powers, might—appealing to the Geneva Convention as an example—bring about such diplomatic steps as would serve to avert the threatened destructive catastrophe from the scientific and art institutions in the metropolis of France.

"In the name of the Royal Bohemian Society of Sciences,

"DR. FRANZ PALACKY, *President.*

"DR. JOH. ER. WOCEL, *General Secretary.*"

The Royal Archæological Institute of Great Britain and Ireland.

16, NEW BURLINGTON-STREET, W.,

28th November, 1870.

"SIR,—I am desired by the Council of the Institute to inform you that I took an early opportunity of directing their attention to the memorial lately adopted by the Royal Irish Academy to Her Majesty's Government in reference to the danger threatening the collections in Paris.

The Council of the Institute enter fully into the apprehensions entertained by the Academy, and sympathize entirely with their anxiety to protect the valuable collections in Paris by all the means in their power.

They trust that the memorial adopted by the Academy will not be without useful results, and they will do their best to further its objects in every way.

"I remain, Sir,
"Very faithfully yours,
"JOSEPH BURTT,
"*Hon. Sec.*

"*W. K. Sullivan, Esq., Secretary Royal Irish Academy.*"

The Historic Society of Lancashire and Cheshire.

"LIVERPOOL, *December 3rd,* 1870.

"SIR,—The Council of our Society met on Thursday evening, and your letter, with the copy of the memorial to Her Majesty's Government which accompanied it, came under our consideration. It seemed to us that by your own action, and the course of events, the apprehended danger had been averted. In this we greatly rejoice, believing with you that any injury to the matchless collections in Paris would be a common loss to all civilized nations.

"Yours very faithfully,
"D. BUXTON, *Hon. Secretary.*

"*The Secretary of the Royal Irish Academy.*"

The Royal Danish Society of Science, Copenhagen.

"A copy of the Memorial to Her English Majesty's Government, adopted by the Royal Irish Academy, at their general meeting, held on Monday, November 14, 1870, as well as the letter by which the Secretary of the Royal Academy solicits the co-operation of the Royal Danish Society, have been laid before this Society in their ordinary meeting, Friday, the 2nd December.

"The Royal Danish Society, sharing the anxiety of the Royal Academy to see preserved the precious collections of Paris, cannot but highly appreciate the efforts of the Academy for the preservation of those collections and express their warmest sympathy.

"However desirous of supporting the Memorial by this expression of sympathy, the Royal Society regret that they cannot do so in a more efficacious way, as they cannot, under the actual circumstances, and for reasons well known to the Academy, entertain any hope as to the success of a diplomatic application from our Government to that of Prussia. (Signed)

"JAPETUS STEENSTRUP,
"*Secretary R. Dan. Soc.*"

The Royal College of Surgeons in Ireland.

"Dublin, *December* 8, 1870.

"Sir—I am directed by the President and Council to acknowledge the receipt of your communication of the 16th ult., and to state in reply that they will co-operate with the Royal Irish Academy to preserve the collections of Paris from the dangers to which they are exposed.

"I remain, Sir,
"Your obedient servant,
"J. Stannus Hughes,
"*Secretary of Council.*

"*W. K. Sullivan, Esq., Ph. D.,*
Secretary of the Academy."

The Royal College of Surgeons of England, London.

"*12th day of December*, 1870.

"Sir,—I have laid before the Council of this College your letter of the 16th ultimo, and accompanying memorial to Her Majesty's Government from the President and Members of the Royal Irish Academy, and I am desired to acquaint you that the Council fully approve of the object sought to be attained by the memorial.

"I am, Sir,
"Your obedient servant,
"Edward Trimmer, *Secretary.*

"*W. K. Sullivan, Esq.,*
Secretary Royal Irish Academy."

The Royal Academy of Science, Letters and Fine Arts of Belgium.

"Academie Royal des Sciences des Lettres
et des Beaux-Arts de Beligique,
"Bruxelles, 12 *Decembre,* 1870.

"Monsieur le Secretaire—Vous aviez sollicité la co-operation de l'Académie à l'adresse que l'Académie royale d'Irlande a adressée au gouvernement de Sa Majesté Britannique, au sujet de l'irréparable perte que causerait, au point de vue de la science, de la littérature et des arts, le bombardement de Paris.

"J'ai eu l'honneur de saisir la classe des sciences de votre communication, dans sa réunion du samedi, 3 de ce mois. La classe, en vous félicitant de vos louables intentions concernant les intérêts de la science, qui sont communs à tous les peuples, s'est vue, à regret, obligeé de ne pouvoir satisfairè à votre demande, par suite de la posi-

tion de l'Académie comme grand corps de l'Etat, retenu par des liens tout a fait speciaux.

"La plus stricte *neutralité* doit présider à nos actes et nous ne pouvons que faire des vœux pour que votre voix soit entendue, afin de prévenir les désastres que vous redoutez à juste titre.

"Veuillez agréer, Monsieur le Secrétairè, l'assurance de mes sentiments les plus distingués.

"*Le Secretaire perpétuel,*

"QUETELET."

[Translation.]

"BRUSSELS, 12*th December*, 1870.

"MR. SECRETARY—You have solicited the co-operation of the Academy to the address which the Royal Irish Academy has addressed to the Government of Her Britannic Majesty, on the subject of the irreparable loss which the bombardment of Paris would cause, from the point of view of Science, of Literature, and of Art.

"I had the honour to lay your communication before the Class of Science at the meeting of Saturday, the 3rd of this month. The Class, while congratulating you on your laudable intentions concerning the interests of Science, which are common to all peoples, sees itself, with regret, unable to satisfy your demand, in consequence of the position of the Academy, as a great body in the State, held by ties quite special.

"The most strict *neutrality* should govern our acts, and we can only hope that your voice may be heard, so as to prevent the disasters which, with good reason, you dread.

"Please accept, Mr. Secretary, of my sentiments the most distinguished.

"*The Perpetual Secretary,*

"A. QUETELET.

"To Mr. SULLIVAN,

"*Secretary to the R. I. A., Dublin.*"

[Translation.]

The Academy of History, Madrid.

"MADRID, 19*th December*, 1870.

"The Academy of History has had the pleasure of receiving a copy of the memorial, which the Royal Irish Academy has forwarded to the Government of Her Britannic Majesty, praying that they might interpose their friendly representations in order that the Scientific, Literary, and Artistic monuments, which Paris contains, and which may be considered as the common property of the whole civilized

world, be respected as far as possible, so as to avoid a case of destruction, similar to that which, in consequence of the war pending, caused the irreparable loss of the celebrated library of Strasburg.

"This Academy, accepting the noble invitation of the Royal Irish Academy, and fully sympathizing in the object of its desires, has presented to the Spanish Government a respectful memorial, praying that it interpose, to the full extent of its influence, in order to secure the preservation, as far as possible, of the grand monuments which Paris contains.

"In conformity with the instructions of the Academy, I inform you of this act, and have the honour to be, with the highest consideration, yours, &c.,

"PEDRO SABAN,

"*Secretary.*

"*The Secretary of the Royal Irish Academy.*"

Letters were also received from the following bodies, declining to interfere, or deeming it inexpedient to take action:—The Zoological Society of London, the Cambridge Philosophical Society, the Trustees of the British Museum, the Royal Dublin Society, &c.

"CONSULAT DE FRANCE EN IRLANDE,

"DUBLIN, *le* 4 *Janvier*, 1871.

"MONSIEUR LE SECRETAIRE—J'ai donné connaissance à mon Gouvernement du mémoire que l'Académie Royale d'Irlande a adopté dans sa séance du 14 Novembre dernier et qu'elle a adressé au Gouvernement de Sa Majesté Brittanique, dans le but de protester contre le projèt attribué à la Prusse de procéder au bombardement de Paris. Je viens de recevoir de Mr. le Comte de Chaudordy, Délégué du Ministre des Affaires Etrangères, à Bordeaux, une lettre dans laquelle il m'écrit que bien que la situation respective des armées Française et Prussienne sous Paris ne laisse pas, quant à présent, d'inquiétude en ce qui concerne l'éventualité qui a ému l'Académie d'Irlande, le Gouvernement ne peut qu'être vivement touché du témoignage de sympathie qu'elle a donné ainsi à la France. Mr. de Chaudordy me charge de vous faire savoir, Monsieur le Sécretaire, que les mesures ont été prises par le Gouvernement de la Défense Nationale pour préserver, autant que possible, les collections littéraires, artistiques et scientifiques contre tout évènement. Il m'invite en même tems à vous transmettre l'expression des sentimens de reconnaissance du Gouvernement et à vous prier de les reporter à Monsieur le Président et aux Membres de votre illustre Compagnie. En me félicitant, Monsieur le Sécretaire, d'être auprés de vous l'interprète de ces sentimens je vous prie de vouloir bien agréer l'assurance de ma considération la plus distinguée.

"LE CONSUL, G. LIVIO."

[Translation.]

"Consulate of France in Ireland,

"Dublin, *4th January*, 1871.

"Mr. Secretary—I made my Government aware of the memorial which the Royal Irish Academy adopted at its meeting of the 14th November last, and which it addressed to the Government of her Britannic Majesty, with the object of protesting against the project attributed to Prussia to proceed to the bombardment of Paris. I have just received from the Count de Chaudordy, delegate of the Minister of Foreign Affairs at Bordeaux, a letter in which he writes, that, although the respective situations of the French and Prussian armies at Paris do not give rise, at least at present, to anxiety as regards the eventuality which has alarmed the Irish Academy, the Government cannot but be deeply touched by the evidence of sympathy which it has thus given to France. M. de Chaudordy has charged me to inform you, Mr. Secretary, that measures have been taken by the Government of National Defence to preserve, as far as possible, the literary, artistic, and scientific collections against all eventualities. He has asked me, at the same time, to transmit to you the expression of the sentiments of gratitude of the Government, and to beg of you to communicate them to the President and the Members of your illustrious body. In congratulating myself, Mr. Secretary, to be the interpreter to you of these sentiments, I beg of you to accept the assurance of my most distinguished consideration.

"G. Livio, Consul."

APPENDIX.

MINUTES OF THE ACADEMY

FOR THE SESSION 1870-71.

FEBRUARY 28, 1871.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following recommendation, brought up by the Secretary of Council, was adopted :—

"That the following allocations be made from the Fund for Promoting Scientific Researches :

"I. To B. B. Stoney, C. E., £10 (additional), 'For experiments on Rivets.'

"II. To R. H. Traquair, M. D., £25, 'For researches on the Cranial Structure of Osseous Fishes.'

"III. To J. E. Reynolds, Esq., £10 (additional), 'For experiments on the Spectra of Chlorides under varying conditions.'"

The following Papers were read :—

"On the difficulties attendant on the transcription of Ogham Legends, and the means of avoiding them." (Part 5th.) By Samuel Ferguson, LL. D.

"On Professors King and Rowney's Paper on 'Eozoon Canadense.'" By T. Sterry Hunt, M. D.

STATED MEETING, MARCH 16, 1871.

Rev. J. H. JELLETT, B. D., President, in the Chair.

The Secretary of Council read the Report of the Council for the year 1870–71.

Sir William R. Wilde moved, and G. T. Macartney, Esq., seconded the following Resolution :—

"That the Report be referred back to Council for the following

recommendation: that after the words 'objects of gold have been,' be introduced, 'removed from the green velvet on which they had been placed some years ago by the Committee of Antiquities, to cases lined by morone coloured cotton plush.'"

The Resolution was carried.

J. J. Digges La Touche, Esq., proposed, and Rev. T. O'Mahony seconded the following Resolution:—

"That that portion of the Report referring to the future publications of Irish MSS. by the Academy, after the manner of the Leabhar na h-Uidhri, be referred back to the Council for further consideration, as to the advisability of accompanying such publications with English translations."

The Resolution was adopted.

Samuel Ferguson, LL. D., proposed, and W. J. O'Donnavan, LL. D., seconded the following vote of thanks to Mr. W. H. Hardinge, for the manner in which he had filled the office of Treasurer:—

"That the Academy receives the resignation of Mr. Hardinge, as Treasurer, with much regret, and desires to record its sense of his valuable services in that office, and to offer him its cordial thanks and good wishes on his retirement."

The following recommendation of the Council of March 6, 1871, was adopted:—

"That the following allocations be made from the Fund for Promoting Scientific Researches.

"I. G. J. Stoney, M. A., £50 'For researches on the interrupted spectra of Gases.'

"II. R. S. Ball, M. A., £6 (additional) 'For experiments on Vortex Rings.'

"III. Henry Hennessy, F. R. S., £20 (additional) 'For experiments on the friction of Fluids in contact with Solids.'

"IV. Thiselton Dyer, Esq., £29 'For Researches on Vegetable Physiology.'"

The following President, Council, and Officers, were elected for the years 1870–71.

PRESIDENT.

Rev. J. H. Jellett, B. D.

COUNCIL.

Committee of Science.

W. K. Sullivan, Ph. D.
Henry Hennessy, F. R. S.
A. Searle Hart, LL. D.

Rev. Samuel Haughton, M. D., F. R. S.
Robert M'Donnell, M. D., F. R. S.
E. Perceval Wright, M. D.
Robert S. Ball, M. A.
Sir Robert Kane, M. D., F. R. S.
Rev. George Salmon, D. D., F. R. S.
George J. Stoney, M. A., F. R. S.
William Archer, Esq.

Committee of Polite Literature and Antiquities.

John T. Gilbert, F. S. A.
William H. Hardinge, Esq.
John Kells Ingram, LL. D.
Sir William R. Wilde, M. D.
Rev. George Longfield, D. D.
Samuel Ferguson, LL. D.
W. J. O'Donnavan, LL. D.
Alexander G. Richey, LL. B.
John R. Garstin, LL. B., F. S. A.
Rev. William Reeves, D. D.

TREASURER.—John R. Garstin, LL. B.

SECRETARY OF THE ACADEMY.—W. K. Sullivan, Ph. D.

SECRETARY OF THE COUNCIL.—John Kells Ingram, LL. D.

LIBRARIAN.—John T. Gilbert, F. S. A.

SECRETARY OF FOREIGN CORRESPONDENCE.—Sir W. R. Wilde, M. D.

CLERK, ASSISTANT LIBRARIAN, AND CURATOR OF THE MUSEUM.—Edward Clibborn, Esq.

The President, under his hand and seal, appointed the following Vice-Presidents for the ensuing year:—

Henry Hennessy, F. R. S.
Rev. Samuel Haughton, M. D., F. R. S.
Sir William R. Wilde, M. D.
Samuel Ferguson, LL. D.

Donations were presented, and thanks voted to the several donors.

APRIL 10, 1871.

Rev. J. H. JELLETT, B. D., President, in the Chair.

Lieut.-Col. F. E. Macnaghten and Brian O'Looney, Esq., were elected Members of the Academy.

William Stokes, M. D., F. R. S., was elected a Member of Council, in place of Rev. George Salmon, D. D., F. R. S., resigned.

The Secretary of Council brought up the report of the Council upon the two points in the Annual Report, referred back to Council at the Stated Meeting of the 16th of March last.

It was moved by the Secretary of Council that the part of the Report referring to the placing of the gold objects on morone velvet, stand part of the Report.

The Resolution was adopted.

The Secretary of Council proposed that the following additional sentence, recommended by the Council, be inserted in the Report:—

"Any translations of pieces from these texts which may be produced, will find an appropriate place in the Irish MSS. series, published by the Academy. And, if a translation of the whole of one of those MSS. should be completed by any competent scholar, the Council will be glad to assist towards its publication, so far as the funds at their disposal will permit."

The proposed addition was adopted.

The Secretary of Council then proposed that the entire Report, as amended, be now adopted, which passed unanimously.

Report.

The Council have pleasure in repeating at the close of another year the testimony they bore in their last Report to the growing prosperity of the Academy. There has been a large addition to the number of our members; our finances are in a satisfactory state; a high degree of intellectual activity has been evidenced by the communications brought before us, especially in the Department of Science; and much has been done towards the greater security and the better arrangement of our Antiquarian Collections, and the provision of increased accommodation for students consulting our Library.

The following Papers in the "Transactions" have been printed since the date of our last Report:—

"On the Small Oscillations of a Rigid Body about a Fixed Point under the Action of any Forces, and more particularly when Gravity is the only Force Acting." By Professor R. S. Ball.

"On the Morphology of Sexes in some Diœcious Plants." By David Moore, Ph. D.

And the following are in the Press:—

"On an Ancient Chalice and Brooches, lately found at Ardagh, in the County of Limerick." By the Earl of Dunraven.

"Additional Observations on Muscular Anomalies in Human Anatomy." (3rd Series.) By Professor Macalister.

In our last Report, Vol. x., Part 4, of the "Proceedings," was announced to be almost ready for issue. It has since appeared, as also

Parts I. and II. of the first volume of a new series, and a third Part is in the printer's hands.

In this new series a distinct pagination has been introduced for the papers on Science, and those on Polite Literature and Antiquities; so that these different portions of our "Proceedings" can be kept apart and bound separately if it should be thought desirable. We are indebted to Rev. Dr. Reeves for the compilation of the Index to Vol. x. We feel deeply the kindness of that distinguished scholar in undertaking, for the benefit of the Academy, in this and previous instances, a task of so laborious and uninteresting a kind.

We have received communications within the past year:—

In Science—From Professor Hennessy, Dr. Sullivan, Professor O'Reilly, Dr. Stokes, Dr. Robert M'Donnell, Mr. R. H. Frith, Dr. Sigerson, Mr. William Andrews, Mr. William Archer, Professor Ball, Mr. C. R. C. Tichborne, Professor Macalister, Mr. G. Johnstone Stoney, Professors King and Rowney, Dr. Dawson, Mr. Charles E. Burton, and Dr. T. Sterry Hunt.

In Polite Literature and Antiquities—From Rev. John O'Hanlon, Dr. Sigerson, Mr. W. H. Hardinge, Mr. D. F. Dowling, Dr. S. Ferguson, Mr. Henry Stokes, Mr. A. G. More, and Mr. R. R. Brash.

At the Stated Meeting on the 30th of November, the President delivered from the Chair an address on the present Condition and Prospects of the Academy, which was soon after issued, in the form of a separate publication, to all the Members, and to the Learned Societies with which the Academy is in correspondence.

Much important work has been executed in the Library, under the superintendence of the Librarian. The unbound tracts and pamphlets, from the close of the sixteenth century to the year 1851, have been arranged and catalogued, and of this Catalogue fifteen volumes have been bound. Progress has been made towards completing defective sets of the publications of Institutions, and towards obtaining the chief home and foreign literary and scientific Journals. The current numbers of these Journals, as well as of Transactions and Proceedings of Learned Societies, may now be found in our Reading-room, immediately after their publication, and a special arrangement has been made in that apartment to render these works readily accessible to students.

Several donations have been received, amongst which may be mentioned the Hydrographical Charts of the Irish Coasts, presented by the Lords of the Admiralty. But far the most important accession to the Library has been the valuable collection of works on Natural History, bequeathed to the Academy by our late distinguished fellow-countryman and fellow-member, Alexander Henry Haliday.

The Catalogue of the Irish Manuscripts has been continued, and the edition of "Leabhar na h-Uidhri," promised in our last Report, has been completed, and is now in the hands of subscribers. We congratulate the Academy on the success of this undertaking, which reflects high credit on the two Irish scholars, Messrs. O'Longan and

O'Looney, through whose zealous labours the text of the original has been so faithfully reproduced. The historical and philological importance, and, arising out of this, the national duty, of publishing accurate copies of our chief Irish texts, appear to be now universally recognized. As a further contribution to this great enterprise, we have resolved to reproduce the valuable manuscript known as "Leabhar Breac." The work has been undertaken by Messrs. O'Longan and O'Looney, and, judging from the portion already executed, we may anticipate in the case of this MS. a result as successful as in that of "Leabhar na h-Uidhri." Owing to the expenses of lithography, the "Leabhar Breac" can be issued only to subscribers, and we hope to receive, in this way, substantial aid towards bringing before the attention of scholars throughout the world so remarkable a monument of the ancient language and literature of Ireland.

Any translations of pieces from these texts which may be produced, will find an appropriate place in the Irish MSS. Series, published by the Academy. And, if a translation of the whole of one of those MSS. should be completed by any competent scholar, the Council will be glad to assist towards its publication so far as the funds at their disposal will permit.

Not many objects have been acquired by purchase for the Museum within the past year. It was mentioned in our last Report that we had made an application to the Government to purchase and deposit in our collection the fine specimens of ancient Irish Art, known as the Ardagh Chalice and the Bell-shrine of St. Patrick. No answer having been received to this application, we thought it right, in December last, to press the matter once more on the attention of the Government. We regret to say that it has been intimated to us in reply that no grant for the purchase of those articles will be proposed to Parliament. By the kindness of the Right Rev. Dr. Butler, the Ardagh Chalice will, for the present, remain as heretofore in the Museum of the Academy.

By the liberality of Dr. Samuel Ferguson, we have become possessed of a considerable number of paper moulds, executed mainly by himself, of inscribed monuments, principally of the Ogham class. It is essential for the profitable study of such inscriptions, 1. That a large number of examples should be brought together for purposes of comparison; 2. That exact reproductions of the originals should be placed at the command of the student; and, 3. That the copies thus supplied should be easily moved, so as to be capable of being placed in various lights, and at convenient points of view. These objects are all admirably attained by the moulds which Dr. Ferguson has presented to the Academy. We hope that other students of such monuments will follow that gentleman's example, and that thus—in accordance with the desire which he has expressed—there may be gradually formed a Paper-cast Museum representing with accuracy all the Inscribed Stones of Ireland which deserve the attention of the antiquary and the philologist.

Immediately after the 16th of March last, the Council nominated a

Committee, to be charged with the supervision of the Museum, the purchase of antiquities, and the administration of the Treasure Trove Fund. Under the superintendence of this Committee, the re-fitting and arrangement of the New Museum has been diligently proceeded with; although, owing to the slow supply of some of the requisite furniture, the air of disorder, inseparable from such a change of repositories, has not yet entirely disappeared from the outer room.

In the inner (or strong) room all the gold objects, together with the Cross of Cong, the Ardagh Chalice, and other articles of the more precious class, have been deposited. The objects in gold have been arranged in the newly-erected iron presses, on a background of morone velvet. An external iron door has been constructed in the entrance, and the important object of placing this part of our collections in absolute security from fire and theft may now be regarded as accomplished.

It has been determined to place the Cross of Cong, the Ardagh Chalice, and some other objects of exceptional interest, on bust-column stands, with turntable tops, carrying cylindrical glass shades, for which directions have been given by the architect. In the case of the Ardagh Cup, an arrangement is contemplated by which the beautiful underwork of the foot will be reflected in a mirror within the glass shade.

In the transfer of these and other parts of the collection, care has been taken to preserve the connexion of the numbers so as to secure the means of reference from the catalogue to each catalogued article in its new locality.

The new furniture prepared and in course of construction for the long room consists of five tables with glass tops. Each table is 4 feet 9 inches wide by 9 feet in length. Four of them are fitted up with sets of drawers, in which the collections to be transferred from the glasscases of the old sets of tables may be temporarily deposited during the process of transfer. The fifth is fitted up with trays for the reception of the Ogham paper casts lately added to the Museum. Two of the former class are still in the hands of the contractor; and glass tops are, as yet, wanting to all. The operations incident to the erection of stoves in the reading-room and library necessitated the removal, for a time, of the Petrie collection from its place in the east gallery of the Reading-room. It is now being re-deposited on glass shelving, and with new methods of attachment, admitting of the removal and replacement of each object.

Having reason to believe that the nature of the existing Treasure Trove Regulations was not generally understood, and that the mass of the population were not aware that the Academy would purchase, at a fair price, any objects of antiquity which might be offered by the finder, we have prepared a statement, in the form of a placard, giving information on the subject, and indicating, by description as well as by woodcuts, the kinds of articles most likely to be found. By the permission of the Commissioners of Education, arrangements have been

made for hanging this placard on the walls of every National School in the country, and we are glad to learn that the same will be done in many other Irish schools. We trust that, in consequence of this measure, many articles which would otherwise be condemned to the melting pot, will be preserved, and find their proper place in the Museum of the Academy.

An object in which the Council is much interested, is the preservation of the architectural and other national monuments of Ireland, which, in too many cases, have suffered, not only from the action of time, but from the hand of man. Our late President was in communication with the Government as to the proper means to be adopted with a view to this end. One of the first steps to be taken for the purpose, is to obtain an exact enumeration of the monuments. We have had, within the past year, an important contribution towards such an enumeration in the elaborate catalogue of those in the County of Kerry, which has been prepared and presented to us by Mr. Henry Stokes.

Out of the sum of £200, placed at the disposal of the Academy, to aid the prosecution of scientific researches requiring expenditure on instruments or materials, the following grants have been made within the year:—

1. To G. Johnstone Stoney, M. A., for Researches on the Refractive Index of Air for each Wave Length, £50.
2. To Mr. B. B. Stoney, for Experiments on Rivets (additional), £10.
3. To Dr. R. H. Traquair, for Researches on the Cranial Structure of Osseous Fishes, £25.
4. To Dr. E. Reynolds, for Experiments on the Spectra of Chlorides under Varying Conditions, (additional), £10.

And it will be recommended to the Academy, at the approaching stated meeting, to sanction the following grants:—

5. To G. Johnston Stoney, M. A., for Researches on the Interrupted Spectra of Gases, £50.
6. To Professor R. S. Ball, for Experiments on Vortex Rings (additional), £6.
7. To Professor Hennessy, for Experiments on the Friction of Fluids in Contact with Solids (additional), £20.
8. To Mr. Thiselton Dyer, for Researches in Vegetable Physiology, £29.

It is a condition of the granting of these sums that the researches thus aided shall be brought before the Academy, and published in its "Transactions" or "Proceedings." We may take the present opportunity of requesting that gentlemen purposing to engage in scientific inquiries in the coming year, and desiring assistance from this fund, will send in their applications to the Council at as early a date as possible.

In the month of November last we thought it incumbent on the Academy to take some action in view of the then probable destruction

of the great scientific, literary, and art collections of Paris by the threatened bombardment of the city. We accordingly prepared a memorial to the Government, requesting them to use their good offices to prevent, as far as possible, any injury to those collections. The memorial was adopted by the Academy, and transmitted, with the signature of the President, to Her Majesty's Principal Secretary for Foreign Affairs, from whom we received a reply, stating that he had forwarded a copy of the memorial to the British Ambassador at Berlin for communication to the Prussian Government. Copies of the memorial were at the same time sent to all the learned bodies with which the Academy has relations, requesting their support towards the attainment of the object in view. We received in reply, besides one or two communications from Germany, couched in language which may be fairly attributed to the excited feeling then prevalent in that country, several others from London, Oxford, Copenhagen, Brussels, Prague, Madrid and Lausanne, expressing entire concurrence in our views and earnest sympathy with our efforts. We are satisfied that, whatever might be the result of our action, in taking the course we did we simply discharged our duty. But the communications of which we have spoken lead us to believe that the timely expression of a strong opinion by this Academy, as the principal scientific and literary body in Ireland, was not without effect in awakening or strengthening the sentiment of cultivated Europe against the destruction of precious collections, which have been accumulated by the labour of many generations, and which are not so much the property of any one nation as the common possession of civilized mankind.

The Academy has lost seven ordinary Members by death within the past year:—

1.	Charles H. Foot, Esq., ...	Elected	1864
2.	Alexander H. Haliday, Esq., M. A., ...	„	1848
3.	Robert Hutton, Esq., F. G. S., ...	„	1816
4.	William Longfield, Esq., ...	„	1859
5.	Rev. Thomas Luby, D. D., ...	„	1833
6.	Acheson Lyle, Esq., M. A., ...	„	1836
7.	Lieutenant-General Sir Charles O'Donnell,	„	1857

And one Honorary member,

Benjamin Thorpe,

an eminent scholar in Anglo-Saxon and Scandinavian Literature and Archæology.

Two of these names we cannot pass over without special notice.

Alexander Henry Haliday was born at Belfast, in November, 1806. He entered Trinity College, Dublin, in his 16th year, and obtained the gold medal in Classics at his Degree Examination in 1827. Shortly afterwards he was called to the Bar, and became a member of the North East Circuit. He was nominated High-Sheriff of the County of Antrim in the year 1843. He had shown from a very early period a marked taste for the study of Natural History, and in 1828 he published in the "Zoological Journal" his first Paper—"On some new Diptera and

Coleoptera captured in the North of Ireland." In 1833 he published a catalogue of the Diptera occurring in the neighbourhood of Holywood, in the county of Down; and in the same year commenced the publication of a series on the Ichneumones minuti of Linnæus. These essays were written in Latin; and, not only by the novelty and interest of the subject, but by the classic elegance of the style in which it was treated, established the author's reputation. A complete list of his many memoirs down to the year 1862 will be found in Dr. Hagen's "Bibliotheca Entomologica." Of these it is sufficient to mention his memoir on the "Affinities of the Aphaniptera among Insects." In 1856 he assisted in establishing in this city the "Natural History Review," a quarterly Journal to which he contributed many reviews and original papers.

Towards the close of 1861 his state of health led him to take up his residence in Italy with a near relative; and soon afterwards he commenced the study of the insects detrimental to the vine and the olive. During occasional excursions to the Campagna, to the Apennines, and to Sicily, he made many valuable additions to the Insect Fauna of Italy. In 1867, with the assistance of Professors Targioni, Tozzetti, and Stefanelli, he founded the Società Entomologica Italiana. He obtained by his personal influence many members in Italy, France, Germany, and England, and contributed largely to the support of the Society and towards the publication of its Bollettino. He numbered amongst his correspondents during the forty years of his active life Coulter, Tardy, Kirby, Sichel, and Curtis, not to mention a host of still living men. Those who knew him best speak in enthusiastic terms of his refined taste and varied erudition, as well as of the nobleness and amiability of his character. He was a member of the Linnæan Society, and of the Entomological Societies of London, Berlin, Stettin, and Paris; and a corresponding member of the Imperial Society of Naturalists at Moscow, and of the Zoological and Botanical Society of Vienna.

He died after a short illness on the 12th of July, 1870, at the residence of his cousin at Lucca. By his will, dated August, 1847, he bequeathed his collection of insects to Trinity College, Dublin, and his valuable library of Natural History to the Royal Irish Academy.

Thomas Luby was born in the year 1799; he entered Trinity College in 1816; graduated as Gold Medallist in Science in 1821; and was elected a Fellow of the College in 1831. He was author of a much-esteemed work on Trigonometry, the first edition of which appeared in 1825; and of a treatise on Physical Astronomy, which was published in 1828. He died at Dublin on the 12th of June, 1870. We are indebted to Dr. Luby for the possession of a very interesting relic. He found amongst the papers of a deceased brother part of a letter from the Rev. Charles Wolfe, containing a complete copy of the celebrated ode on the burial of Sir John Moore. By Dr. Luby's desire, Dr. Anster exhibited the letter at one of our meetings in the year 1841. Dr. Luby afterwards presented it to the Academy, and it is preserved in our Library.

Twenty-one ordinary Members have been elected during the past year:—

1. Richard Joseph Cruise, Esq.
2. Sir Arthur Guinness, Bart.
3. John Vickers Heily, M.D.
4. George Macartney, Esq.
5. Thomas F. Pigot, Esq., C.E.
6. Joseph Watkins, Esq., R. H. A.
7. Abraham Fitz-Gibbon, Esq., C. E.
8. Emanuel Hutchins, Esq.
9. John Kelly, Esq.
10. John P. Keane, Esq., C. E.
11. Hugh Leonard, Esq.
12. Right Hon. the Earl of Rosse.
13. The Lord Ventry.
14. Robert D. Joyce, M. D.
15. Very Reverend Ulick J. Bourke.
16. George Woods Maunsell, Esq., M. A.
17. John Symons, Esq.
18. Ramsey H. Traquair, M. D.
19. Rev. P. Shuldham Henry, D. D.
20. Henry Dix Hutton, Esq. LL. B.
21. J. W. Ellison Macartney, Esq.

One Honorary Member has been elected in the Department of Polite Literature and Antiquities:—

Professor Heinrich Ewald, of Göttingen.

The following Recommendation of the Council of 3rd April, 1871, was unanimously adopted:—

"That the Academy purchase the Bell and Bell Shrine of St. Patrick from Dr. Todd, for £500, and that the Council be authorised to make such arrangements for the payment of that sum as the funds of the Academy will permit."

The following Papers were read:—

"On the Floatation of Sand by the incoming tide at the mouth of a tidal river." By Professor Hennessy, F. R. S.

"On the Mineral Origin of the so-called 'Eozoon Canadense.'" By Professors William King, Sc. D., and Thomas H. Rowney, Ph. D.

"Addendum to a Paper on Eozoon." By Principal Dawson, of M'Gill College, Montreal.

A vote of thanks was passed to Professors King and Rowney for their Paper.

Donations were received, and thanks voted to the several donors.

APRIL 24, 1871.

Rev. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"Report on the Molecular Dissociation by Heat of Compounds in Solution." By Charles R. C. Tichborne, F. C. S. L.

"On the Irish Tract, by Œngus the Culdee, on the Mothers of the Saints of Ireland." By the Rev. William Reeves, D. D.

The following Donations were presented by Miss Stokes, and thanks voted:—

"Descriptive Remarks on Illuminations in certain ancient Irish MSS." By Rev. J. H. Todd, D. D.

"The Cromlech on Howth."

"The Breac Moedog."

"Christian Inscriptions in the Irish Language." By M. Stokes.

MAY 8, 1871.

REV. J. H. JELLETT, B. D., President, in the Chair.

Right Hon. Patrick Bulfin, Lord Mayor of Dublin, was elected a Member of the Academy.

The following Papers were read:—

"A Second Report on the Researches of Professor Cohnheim on Inflammation and Suppuration." By J. M. Purser, M. B.

"On the Ancient Name of Hibernia." By Hyde Clarke, Esq.

The Secretary presented, on the part of Charles Todd, LL. D., the copy of Bishop Bedell's Irish Bible, which had been kept with the bell and bell-shrine of St. Patrick, now in possession of the Academy.

Donations were presented, and thanks voted to the several donors.

GENERAL ABSTRACT OF THE ACCOUNT OF W. H. HARDI

FROM 31st MARCH, 1

CASH RECEIPTS.

Heads of Account.	Amount in Detail. £	s.	d.	Gross A of each
Special Receipts.				
Vote of Parliament for Preparation of Scientific Reports, . .	200	0	0	
Vote of Parliament for a Museum Clerk and objects connected with the study of Antiquities, ...	200	0	0	
Vote of Parliament for a Library Clerk and for cost of Books and Binding, ...	200	0	0	
Vote of Parliament for Salary of an Irish Scribe, and for Printing and Cataloguing Irish Manuscripts, ...	200	0	0	
Vote of Parliament for illustrating Transactions and Proceedings,	200	0	0	
Vote of Parliament for Treasure Trove, ...	100	0	0	
,, for Continuation of Museum Catalogue, Produce of its Sales and Interest of its Bank of Ireland Stock (Gross Stock, £24 11*s.* 2*d.*), ...	5	14	4	
Interest of the Cunningham Bequest and unappropriated Savings funded in New 3 per cent. Stock (Gross Stock, £2245 11*s.*),	66	2	1	
Life-Compositions for Annual Subscriptions invested in Consol Stock (Gross Stock, £1975 9*s.* 0*d.*)	38	1	0	
				1209 1
Receipts for General Purposes.				
Cash balance on 1st April, 1870, { Transact. & Proceedings, £78 18 9; Treasure Trove, ... 77 0 0; General Purposes Heads, 248 14 0 }	399	12	9	
Government Old Grant, ...	584	0	0	
Annual Subscriptions of Members, ...	273	0	8	
Subscriptions to Leabhar na h-Uidhri, ...	84	0	0	
Entrance Fees of Members, ...	110	5	6	
Interest of Life Composition, Consol Stock, ...	57	1	2	
Sales of Publications through Booksellers, ...	...			
Sales of Transactions and Proceedings through do., . . .	...			
Do. do. in Academy, ...	0	6	6	
Subscriptions to Tea and Coffee Fund, ...	11	16	6	
Miscellaneous, ...	5	5	0	
Subscriptions to Leabhar Breac, ...	5	5	0	
				1530 1
				£2740

This Account and Bank Balance Reconciling Abstract :—

Balance, per B k Certificate, ...				£984	13	9
Add, in Mr. Clibborn s hands for Incidents, ...	£8	1	2			
,, Mr. Hodges' hands, for Postage,	1	17	1			
				9	18	3
This Account Balance, . . .				£994	12	0

I solemnly and sincerely declare that the above Account is just and true, according t *true.*

Declared before me at D (Sig

TREASURER OF THE ROYAL IRISH ACADEMY,

TO 17TH MARCH, 1871.

CASH PAYMENTS.

Heads of Account.	Amount in Detail. £	s.	d.	Gross Amount of each Class £	s.	d.
SPECIAL APPROPRIATIONS.						
For Preparation of Scientific Reports,	50	0	0			
For Museum Objects, as contra,	98	6	8			
For Library Objects, as contra,	200	0	0			
For Irish Scribe, &c., as contra,	181	2	11			
For Publishing and Illustrating Transactions and Proceedings, and Leabhar na h-Uidhri,	273	18	9			
For Purchase of Treasure Trove,	17	14	7			
For Continuation of Museum Catalogue, or Purchase of Bank of Ireland Stock (Stock Equivalents, £2 5s. 1d.),	5	14	4			
(The Interest of Cunningham Fund Stock was distributed moietively by Council, to be expended by the Science Committee and Pol. Lit. & Antiq. Com., the Treasurer did not, therefore, purchase contra Interest of £66 2s. 1d. into this Stock)						
For equivalent of Consol Stock (£41 5s. 9d.),	38	1	0	864	18	3
GENERAL PURPOSES APPROPRIATIONS.						
In aid of Parliamentary Grant for Library Objects,	53	7	5			
Do. do. for Illustrating and Printing Transactions and Proceedings, and Leabhar na h-Uidhri,	205	4	11			
Salaries,	286	10	0			
Wages and Liveries,	146	5	0			
Stationery,	15	15	4			
Miscellaneous Printing,	17	5	9	724	8	5
CONTINGENCIES.						
Gas,	32	18	1			
Coals,	29	19	0			
Furniture and Repairs,	17	18	3			
Tea Fund,	25	6	11			
Taxes and Insurance,	8	2	6			
Contingencies (Special),	0	14	5			
Discounts on Drafts Lodged,	0	4	9			
Incidents, per Mr. Clibborn,	21	2	8			
Postage, per Mr. Hodges,	20	4	10			
				156	11	5
				1745	18	1
Balance to credit of next Treasurer's Account, commencing March 17, 1871,				994	12	0
				£2740	10	1

Foregoing General Abstract examined by us, and found correct. Balance due by Treasurer, Nine Hundred and Ninety-four Pounds Twelve Shillings, Sterling.

(Signed) M. H. CLOSE.
WILLIAM ARCHER.

April 28, 1871.

knowledge and belief; and I make this solemn declaration conscientiously believing the same to be
W. H. HARDINGE, *Treasurer, R. I. A.*

23rd day of March, 1871,
. O'FERRALL.

GENERAL ABSTRACT OF THE COMBINED ACCOUNTS O
TREASURERS OF TH

FOR THE YEAR FROM 31s

RECEIPTS.

Heads of Account.	Amount in Detail. £	s.	d.	Gross Amo of each Cl
Special Receipts.				
Vote of Parliament for Preparation of Scientific Reports, . .	200	0	0	
Vote of Parliament for Museum Clerk and objects connected with the study of Antiquities, ...	200	0	0	
Vote of Parliament for Library Clerk and for cost of Books and Binding, ...	200	0	0	
Vote of Parliament for Salary of an Irish Scribe, and for Printing and Cataloguing Irish Manuscripts, ...	200	0	0	
Vote of Parliament for illustrating Transactions and Proceedings,	200	0	0	
Vote of Parliament for Treasure Trove, ...	100	0	0	
For Continuation of Museum Catalogue: Produce of its Sales, and Interest of its Bank of Ireland Stock (Gross Stock, £24 11*s.* 2*d.*), ...	6	8	8	
Interest of the Cunningham Bequest and unappropriated Savings: funded in New 3 per cent. Stock (Gross Stock, £2245 11*s.* 0*d.*),	66	2	1	
Life Compositions for Annual Subscriptions: invested in Consol Stock (Gross Stock, £1975 9*s.* 0*d.*), ...	88	1	0	
				1210 11
Receipts for General Purposes.				
Cash Balance on 1st April, 1870, { Transact. & Proceedings, £73 18 9; Treasure Trove, . . . 77 0 0; General Purposes Heads, 248 14 0 }	399	12	9	
Government Old Grant, ...	584	0	0	
Annual Subscriptions of Members, ...	287	14	3	
Subscriptions to Leabhar na h-Uidhri, ...	86	2	0	
Entrance Fees of Members, ...	110	5	6	
Interest of Life Composition Consol Stock, ...	57	1	2	
Sales of Publications through Booksellers, ...	.	.	.	
Sales of Transactions and Proceedings through Booksellers, .	.	.	.	
Sales of Transactions and Proceedings in Academy, . . .	0	6	6	
Subscriptions to Tea and Coffee Fund, ...	11	16	6	
Miscellaneous, ...	5	5	0	
Subscription to Leabhar Breac, ...	5	5	0	
				1547 8
				£2758 0

This Account and Bank Balance Reconciling Abstract:—

Balance per Bank Certificate, ...				£513	1	1
Add, in Mr. Clibborn's hands for Incidents, ...	£5	18	1			
„ Mr. Hodges' hands for Postage,	1	7	9			
				7	5	10
				520	6	11
Deduct, Outstanding Drafts, viz.:—						
Nos. 96 and 112, ...				313	14	7
This Account Balance				£206	12	4

I certify that the above Account is just and true, according to the best of m

W. H. HARDINGE AND J. R. GARSTIN,
ROYAL IRISH ACADEMY,

MARCH, 1870, TO 1st APRIL 1871.

PAYMENTS.

Heads of Account.	Amount in Detail. £ s. d.	Gross Amount of each Class.
Special Appropriations.		
For Preparation of Scientific Reports,	200 0 0	
For Museum Objects, as contra,	200 0 0	
For Library Objects, as contra,	200 0 0	
For Irish Scribe, &c., as contra,	200 0 0	
For publishing and illustrating Transactions, Proceedings, and Leabhar na h-Uidhri,	273 18 9*	
For Purchase of Treasure Trove,	177 0 0*	
For Continuation of Museum Catalogue or Purchase of Bank of Ireland Stock (Stock Equivalent, £2 5*s.* 1*d.*),	5 14 4	
For Equivalent of New 3 per cent. Stock (£72 2*s.* 6*d.*),	66 2 1	
For Equivalent of Consol Stock (£41 5*s.* 9*d.*),	38 1 0	
		1360 16 2
General Purposes Appropriations.		
Balance due to Bank,	....	
In aid of Parliamentary Grant for Scientific Reports,	....	
Do. do. for Museum Objects,	50 0 0	
Do. do for Library Objects,	80 4 4	
Do. do for illustrating and printing Transactions, Proceedings, and Leabhar na h-Uidhri,	206 6 10	
In aid of Parliamentary Grant for Irish Scribe, &c.,	61 0 0	
Do. do. for Treasure Trove,	....	
Salaries,	334 0 0	
Wages and Liveries,	154 16 0	
Stationery,	23 1 1	
Miscellaneous Printing,	20 8 10	
For Polite Literature and Antiquity objects,	100 0 0	
		1029 17 1
Contingencies.		
Gas,	32 18 1	
Coals,	29 19 0	
Furniture and Repairs,	19 9 0	
Tea Fund,	25 6 11	
Taxes and Insurance,	8 2 6	
Contingencies (Special),	0 14 5	
Discount on Drafts lodged,	0 5 0	
Incidents, per Mr. Clibborn,	23 5 9	
Postage, per Mr. Hodges,	20 14 2	
		160 14 10
		2551 8 1
Balance to credit of next year's Account,		206 12 4
		£2758 0 5

* The excess over Government Grants in each of these heads is the under expenditure of the last year's Grants. See contra, Cash Balance.

*** For Auditors' Report, see next page.

knowledge and belief,

JOHN RIBTON GARSTIN, *Treasurer*, *R. I. A.* (since March 16th, 1871).

AUDITORS' REPORT.

We have examined the above General Abstract, and compared the vouchers for the details of the several heads thereof, and find it to be correct, leaving a balance of (£206 12*s*. 4*d*.) two hundred and six pounds twelve shillings and four pence to the credit of the Academy.

The Treasurer has exhibited to us Certificates of the Accountant-General, showing the Balance in the Bank of Ireland on the 1st of April, to the credit of the Academy, to be five hundred and thirteen pounds one shilling and one penny; and like Certificates showing the amount of Government Stock held by the Academy to be £2245 11*s*. 0*d*. New three per cents. (besides Transfer Certificate for £72 2*s*. 6*d*. of the same, the purchase of which was not completed until after the 1st of April); and £1975 9*s*. 0*d*. Consols; together with £24 11*s*. 2*d*. Bank of Ireland Stock.

(Signed) WILLIAM ARCHER, M. H. CLOSE, } *Auditors.*

APPENDIX.

MINUTES OF THE ACADEMY

FOR THE SESSION 1870-71.

MAY 22, 1871.

REV. J. H. JELLETT, B.D., President, in the Chair.

The following Papers were read:—

"On Optical Saccharometry, with special reference to an examination of Sugar Beet grown in Ireland;" by the President.

"On the comparative chemical composition of ancient Bronzes, in connexion with the Ethnology, Metallurgy, and Commerce of the ancient peoples of Europe;" by W. K. Sullivan, Ph. D.

JUNE 12, 1871.

REV. J. H. JELLETT, B.D., President, in the Chair.

William A. T. Amhurst, Esq., J.P., D.L.; Captain Richard Cooper; Whitley Stokes, Esq.; Col. Frederick Tyrrell, J.P., were elected Members of the Academy.

The following Papers were read:

"On the Absorption Spectrum of Chloro-chromic Anhydride;" by G. J. Stoney, F.R.S., and Dr. J. Emerson Reynolds.

"On the great Dolomite Bed of the North of Spain, in connexion with the Tithonic Stage of Prof. Opel." By Profs. W. K. Sullivan, Ph. D., and J. P. O'Reilly, C. E.

"Additions to the Flora of Botanical District No. 10 [Ireland]," also, "On an anomalous form of Corolla of Erica;" by G. Sigerson, M. D., F. L. S.

A "Note on Leabhar na h-Uidhre;" by Brian O'Looney, Esq.

Donations were presented, and thanks voted to the several donors.

JUNE 26, 1871.

REV. J. H. JELLETT, B.D., President, in the Chair.

The following Papers were read:—

"Note on the remains of fish in the alluvial clay of the river Foyle;" by G. Sigerson, M. D., F. L. S.

"Topography of the County of Armagh" [1st part]; by Rev. William Reeves, D.D.

"On a new form of Spectroscope;" by G. J. Stoney, M.A., F.R.S.

"On the Respiration of Compressed Air;" by Thomas Hayden, F.R.C.S.I., &c.

Donations were presented, and thanks voted to the several donors.

APPENDIX.

MINUTES OF THE ACADEMY

FOR THE SESSION 1871-72.

NOVEMBER 13, 1871.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"On the Félire of Œngus;" by Whitley Stokes, LL. D.

"Notes on the Andaman Islands;" by Robert S. Ball, LL. D., for Valentine Ball, Esq.

"On a Geometrical Study of the Kinematics, Equilibrium, and small Oscillations of a Rigid Body;" by Robert S. Ball, LL. D.

"On the Granitic and other Ingenite Rocks of the Mountainous Tract of Country west of Loughs Mask and Corrib;" by G. H. Kinahan, Esq.

The thanks of the Academy were voted to the Chevalier Nigra, for his donation of Photographs of a part of the Turin Manuscript.

STATED MEETING, NOVEMBER 30, 1871.

REV. J. H. JELLETT, B. D., President, in the Chair.

It was proposed by G. H. Kinahan, Esq., &c., and seconded by J. T. Gilbert, Esq., F. S. A., and resolved:—

"That it be recommended to Council to consider the expediency of having the 'Notice to Finders of Antiquities,' printed in the Irish language for circulation in the Irish speaking districts."

The Donations to the Library and Museum were presented, and thanks voted to the several donors.

The following papers were read:—

"Observations on Earl Stanhope's Alleged Imperfections of the Tuning Fork;" by the Secretary, for M. Donovan Esq.

"On the Bodleian Fragment of Cormac's Glossary;" by the Secretary, for Whitley Stokes, LL. D.

"On a New Type of Clochan, in the County of Mayo;" by G. H. Kinahan, Esq.

DECEMBER 11, 1871.

HENRY HENNESSY, F. R. S., Vice-President, in the Chair.

The Chairman remarked that the present meeting was held under gloomy and painful circumstances owing to the very serious illness of the Prince of Wales. Steps had been taken to ascertain the latest authentic intelligence regarding the condition of the Prince, and if the news happened to be of a disastrous nature the Academy would have at once adjourned; but as the latest telegram which had been received stated that the strength of His Royal Highness still kept up, it would happily not be necessary to do so, and they might accordingly proceed with the business on the notice paper.

The following papers were read:—

"Notes on Applied Mechanics:—1, Parallel motion; 2, Sliding and Rolling Contact;" by Robert S. Ball, LL. D.

"On Ogham Pillar Stones;" by the Secretary, for Hodder M. Westropp, Esq.

"Notes on an Ancient Irish Tract on Omens and Dreams;" by Brian O'Looney, Esq.

JANUARY 8, 1872.

HENRY HENNESSY, F. R. S., Vice-President, in the Chair.

"On the Action of Heat upon Solutions of Hydrated Salts;" by C. R. C. Tichborne, F. C. S., &c.

"Notes of Observations of Phenomena in Optical Meteorology;" by Henry Hennessy, F. R. S., &c.

The thanks of the Academy were presented to Rev. Arthur Dawson for his donation of a bust of his father, the Very Rev. Henry R. Dawson, Dean of St. Patrick's, Dublin.

Ten roundels were presented by W. H. Gregory Esq., M. P., through Charles Todd, LL. D., which had been in the care of the late Rev. James H. Todd, D. D., ex-president of the Academy.

A centenary medal and Gedenkbuch of the hundredth anniversary of the foundation of the Royal Hungarian Mining and Forestry Academy of Schemnitz, presented by the Academy, was laid on the table.

Donations to the Library were presented, and thanks voted to the several donors.

FEBRUARY 12, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following recommendations, brought up by the Secretary of the Council, were adopted:—

That the following allocations be made from the Fund for Promoting Scientific Researches:

I. To C. R. C. Tichborne, £50, for Researches on the Dissociation of Salts in Hot Solutions, and on the History of the Terebenes.

II. To E. T. Hardman, £30, for Chemico-Geological Researches.

III. To R. S. Ball, LL. D., £25, for Researches on the Motion of Vortex Rings.

IV. To S. Downing, LL. D., £25, for Researches on the Motion of Water through Curved Tubes.

V. To P. S. Abraham, £50, for Researches on the Coast of Madeira.

The following papers were read:—

"On the Identification of the Ancient Cemetery at Loughcrew, Co. of Meath;" by Eugene A. Conwell, LL. D.

"On Several Finds of Coins lately made in Ireland;" by William Frazer, M. D.

Donations to the Library were presented, and thanks voted to the several donors.

FEBRUARY 26, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following papers were read:—

"On the Identification of St. Malachy O'Morgair's old Cœnobium Ibracense;" by the Rev. John O'Hanlon.

"On the Cemeteries of Croaghan and Usnaght;" by S. Ferguson, LL. D.

In the absence of Skiffington Daly, Esq., the Secretary presented from Lord Dunsandle, a large bronze riveted cauldron, found in Carrownkelly Bog, near Dunsandle, Co. Galway.

The Secretary read a list of books recently presented to the Library.

The thanks of the Academy were voted to the several donors.

STATED MEETING, MARCH 16, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

The Secretary of Council brought up the Report of the Council for the year 1871-1872.

REPORT.

SINCE the date of our last Annual Report, Vol. I., Part III. of the New Series of the Proceedings of the Academy has been completed and issued to Members. Part IV. is ready for issue, and Part V. is in the press.

The following papers for the "Transactions" are also in the press, and will soon appear:

In Science—

1. "On Muscular Anomalies in Human Anatomy." By Professor Macalister.

2. "Account of Experiments on the Retardation experienced by Vortex Rings of Air, when moving through the Air." By Professor R. S. Ball.

3. "A Geometrical Study of the Kinematics, Equilibrium, and small Oscillations of a Rigid Body." By Professor R. S. Ball.

And, in Polite Literature and Antiquities—

1. "On an Ancient Chalice and Brooch lately found at Ardagh, in the county of Limerick." By the late Earl of Dunraven.

2. "On the Felire of Oengus." By Whitley Stokes, LL. D.

Papers have been read before the Academy during the year:

In the department of Science—By the President; by R. S. Ball, LL. D.; Mr. C. R. C. Tichborne; Mr. G. J. Stoney; J. M. Purser, M. B.; Thomas Hayden, M. D; Professor Hennessy; W. K. Sullivan, Ph. D.; G. Sigerson, M. D.; Mr. Michael Donovan; Mr. G. H. Kinahan; Professor J. P. O'Reilly; Principal Dawson; and Professor King.

In the department of Polite Literature and Antiquities—By the Rev. W. Reeves, D. D.; Samuel Ferguson, LL. D.; Eugene A. Conwell, LL. D.; Whitley Stokes, LL. D.; the Rev. J. O'Hanlon; William Frazer, M. D.; Mr. Valentine Ball; Mr. Brian O'Looney; Mr. G. H. Kinahan; Mr. Hodder M. Westropp; and Mr. Hyde Clarke.

The transfer of the collection of Antiquities to their new places of deposit in the Long Room has been continued during the year, and is still in progress. The original classification has been preserved, and the objects placed—so far as was practicable—in the same order and sequence as in the old Museum. The details of the operation are recorded in books drawn up on a uniform plan, by which each object described in the Catalogue may be found in its new place of deposit, and the description of each object so deposited may be found in the Catalogue. The Stone Collection (with some trifling exceptions) has been placed, and considerable progress has been made in the deposit of the objects of clay and wood. The limited space at our disposal has rendered it necessary to enlarge several of the presses, and to furnish all with new fittings—an operation which has occupied much time, and retarded the completion of the transfer.

The Ardagh Chalice and Brooches, which, by the kindness of the Right Rev. Bishop Butler and the late Earl of Dunraven, had been for

a considerable time deposited in the Museum, have been returned by the Council, at the request of the persons authorized to receive them. In expressing our satisfaction at their having been allowed to remain so long in our collection, we took occasion to express the hope that, at some future time, an opportunity might be afforded to the Academy of acquiring permanently for its Museum those beautiful specimens of ancient Irish Art.

A Reliquary, the property of the Right Hon. William Monsell, M. P., which had been deposited in the Museum, has also been returned to that gentleman at his request.

The Bell and Bell-shrine of St. Patrick, the price of which was originally fixed at £700, having been liberally offered by its owner, Dr. Charles H. Todd, for the reduced price of £500, provided they were bought by, or for, the Academy, it was resolved by the Academy, on the recommendation of the Council, to purchase them. The Council were, at the same time, authorized to make such arrangements as they should deem expedient for providing the required amount. The Bell and Bell-shrine were accordingly obtained, and placed in the Museum; and, of the purchase-money, a sum of £307 14*s.* 7*d.* has been paid to Dr. Todd out of the funds of the Academy.

In submitting to Her Majesty's Government the usual statement of the requirements of the Academy for the year 1872–3, we thought it right to append to the ordinary estimate several supplementary items, together with a statement explanatory of the grounds on which we applied for these additional sums. First, in order to meet the cost of attendance and general expenses which would necessarily be incurred in opening the Museum fully to the public, we asked for an additional annual grant of £200. We also applied for a grant of £200, to enable us to publish materials prepared by the aid of the sum placed at our disposal for the furtherance of Researches in connexion with Irish Manuscripts. Thirdly, we asked that the Government should supply the amount required to complete the price of the Bell and Bell-shrine above spoken of. And, lastly, Dr. Aquilla Smith's valuable collection of Irish Coins and Tokens being offered to us for the sum of £350, we requested that it should be purchased for the Academy, and that thus a body of materials so important for the study of Irish Numismatics should be kept in this country, and find its only appropriate place in our National Museum. It has been intimated to us that the Government have decided to provide in the estimates for the year the sum required to complete the price of the Bell and Bell-shrine; but we regret to say that they decline to accede to the other portions of our application. The Smith Collection of Coins must, however, not be lost to Ireland, and we therefore propose that the Academy should purchase the collection, and—as in the case of the Bell and Bell-shrine—should authorize the Council to make the necessary financial arrangements for the purpose.

The Notice to Finders of Antiquities, which has been extensively circulated in English, has, in accordance with a recommendation of the

Academy, been translated into Irish, for circulation in those districts of the country where that language is spoken.

The Collection of Books on Entomology bequeathed to the Academy by the late Alexander H. Haliday has been received, and placed in the Library. A catalogue of the collection has been prepared, and is now being printed.

The arrangement for keeping the Reading-room and Library open till 5.30 p.m. has been continued, and all possible facilities are afforded for consulting works in the Library.

The cataloguing of our Irish Manuscripts has been continued, and has now come down as far as the Hudson Collection.

In the lithographing of Leabhar Breac much progress has been made, and we have the gratification of now laying before the Academy a copy of nearly one-half of the entire of this fine Manuscript, which, in respect of accuracy and style of execution—notwithstanding the extreme intricacies of portions of the original—will, we believe, be found to sustain the reputation of Mr. O'Longan, by whom the text has been reproduced, and of our fellow-member, Mr. O'Looney, by whom it has been collated. It is intended that this first half of Leabhar Breac shall be issued to subscribers as soon as possible; and we hope that, at the date of our next Report, the second and concluding part will be far advanced towards completion. The publication for the first time of this ancient Manuscript in its integrity cannot fail to be productive of valuable results in the promotion, at home and abroad, of the study of our national language and history. The volume, too, it may be observed, will be interesting in relation to other than purely Celtic matters: several curious pieces will be found in it, written in intermixed Latin and Irish, referring to early Christian history and kindred subjects.

We have received an important contribution to Irish archæological and linguistic studies from Whitley Stokes, LL. D., in his triple-text edition of the "Felire of Oengus Celé Dé," now in process of printing for the Transactions. We have also to announce the production of a complete translation of "Leabhar na-h-Uidhri," by Mr. O'Looney, which that gentleman has liberally offered to the Academy for publication.

We have added a number of Societies in Europe and America to the list of learned Bodies with which we exchange Transactions.

It having become necessary to reprint the By-Laws, and several changes therein being desirable, the Council, deeming the opportunity favourable, appointed a Committee to prepare the draft of a revised edition of the By-Laws, and the result of their labours will soon be laid before you.

Out of the sum of £200 annually placed at the disposal of the Academy, for the assistance of Scientific Researches involving expenditure for instruments or materials, the Council have made the following grants, which have been confirmed by the Academy, viz.:

To Mr. C. R. C. Tichborne, for Researches on the Dissociation

of Salts in Hot Solutions, and on the History of the Terebenes, £50.

To Mr. E. T. Hardman, for Chemico-Geological Researches, £30.

To Professor R. S. Ball, for further Researches on the Motion of Vortex Rings, £25.

To Professor S. Downing, for Researches on the Motion of Water through Curved Tubes, £25.

To Mr. P. S. Abraham, for Researches on the coast of Madeira, £50. And the Academy will be asked, at the stated Meeting, to sanction the grant of the remaining portion of the fund (after deduction of expenses)—viz., £19. 4*s*. 9*d*., to Mr. Charles P. Cotton, for Researches on the Strength, Stiffness, &c., of Bent Iron Plates.

The following Members were elected within the past year:

1. Lieutenant-Colonel Francis E. Macnaghten.
2. Brian O'Looney, Esq.
3. Right Hon. Patrick Bulfin, Lord Mayor of Dublin.
4. W. A. T. Amhurst, Esq.
5. Captain Richard Cooper.
6. Whitley Stokes, Esq., LL. D.
7. Colonel Frederick Tyrrell.

The Academy has lost by death within the year ten ordinary members, viz.:

Right Hon. Patrick Bulfin, Lord Mayor of Dublin, elected May 8, 1871.

John E. Pigot, Esq., elected June 9, 1851.

Rev. T. D. F. Barry, elected January 8, 1866.

Joseph Watkins, Esq., R. H. A., elected April 11, 1870.

Right Hon. Edwin R. Windham Wyndham, Earl of Dunraven and Mount-Earl, F. R. S., elected October 25, 1830.

Robert Callwell, Esq., elected February 10, 1838.

George Alexander Hamilton, Esq., LL. D., elected January 13, 1845.

Right Hon. Edward Lucas, elected January 13, 1845.

James Graham Hildige, Esq., F. R. C. S. I., L. K. Q. C. P. I., elected January 10, 1859.

William D. Moore, M. D., elected December 12, 1859.

One of the Members we have lost took a very earnest interest and an active part in the work of the Academy—we mean Lord Dunraven. He was born at Adare Manor, in the county of Limerick, on the 19th of May, 1812. He was educated at Eton, and Trinity College, Dublin. In early life he was devoted to the study of astronomy, and resided for about two years at the Dublin Observatory, where he earnestly occupied himself with observing-work, under the direction of Sir William R. Hamilton. These labours proved detrimental to his sight, and in consequence of this he abandoned a project he had formed of erecting a first-class observatory at Adare. He always, however, retained a great interest in the science, and became a Fellow of the Royal Astronomical Society. So early as 1830, when he was but in the 19th year of his age, he was elected a Member of this Academy, of

which he afterwards became a Member of Council and Vice-President. It seems to have been his intimate friendship with Petrie that first led him to the serious study of archæology. He co-operated earnestly in the establishment of the Irish Archæological Society, founded in 1840, and afterwards in that of the Celtic Society, in 1845.

In common with all enlightened Irishmen, he had felt much disappointment and regret when the operations of the Topographical department of the Ordnance Survey were stopped by the Government, after the publication of the Londonderry Memoir. In 1843 it was resolved to take action, for the purpose of endeavouring to induce Her Majesty's Ministers to sanction the recommencement and continuance of those operations. In January of that year the Academy appointed a deputation to present a memorial on the subject to the Irish Government. Lord Dunraven (then Viscount Adare), acting in concert with his Irish friends, brought together a large and influential meeting in London, on the 19th of June, in the same year. The result of the efforts thus made was, that the then Prime Minister, Sir Robert Peel, consented to the appointment of a Commission to reconsider the entire question. Lord Adare was a member of this Commission. Some of the leading scholars of Ireland were examined before it, and a highly-interesting Report, based on their evidence, was presented to the Government. That Report was in favour of the resumption of the Geological Survey and the continuance of the Topographical and Historical department concurrently with it, though on a separate basis. The recommendations, so far as the latter was concerned, were not carried into effect; and, in that respect, the Commission bore no fruit. But the movement in which our deceased Member had taken such a prominent part led to the establishment of the Geological Survey of the United Kingdom, which De La Beche in England and Portlock in this country had commenced, but which, up to the period of the labours of the Commission of 1843, had received very little encouragement or support from the Government.

On the discovery of the Ardagh Chalice and Brooches, Lord Dunraven procured for us, as we have already had occasion to mention, the privilege of exhibiting in our Museum, for a considerable time, those valuable works of art. And we have reason to know that it was his earnest desire that they might ere long become the property of the Academy. He gave an elaborate account of them in a Paper read before us, and which will soon appear in our Transactions.

For some years before his death he was engaged in preparing materials for the completion of Dr. Petrie's "History of the Ancient Ecclesiastical Architecture of Ireland." He had personally visited all the principal ruins, and had taken photographs, and made ground plans and measurements of them, and written descriptive notes. He made provision in his Will for the publication of these photographs, which will supply a series of illustrations of Irish Architecture, from its earliest period down to the Norman Invasion.

Lord Dunraven was President of the Cambrian Archæological Asso-

ciation in 1869, when it met at Bridgend, in Glamorganshire, and he delivered before that body a valuable address on the Archæology of the district.

He was a Fellow of the Royal Society, of the Royal Geographical, and of the Geological, Societies.

Lord Dunraven died at Malvern, on the 6th of October, 1871.

The Academy has also lost by death, within the year, four Honorary Members, viz.:—

Sir Roderick Impey Murchison, Bart., D. C. L., F. R. S.
Charles Babbage, Esq., M. A., F. R. S.
Sir John Frederick William Herschel, Bart., D. C. L., F. R. S.
George Grote, Esq.

No Honorary Member has been elected.

The Report was adopted.

The Secretary of the Council brought up the following recommendations of the Council, which were adopted.—

I. To authorize the Council to purchase Dr. Aquilla Smith's collection of Irish Coins and Tokens for £350; and to make such arrangements for the payment of that sum as the funds of the Academy will permit.

II. To allocate to Mr. Charles Cotton the sum of £19 14*s*. 9*d*., being the Balance of the Parliamentary grant, in aid of his researches "On the Stiffness, &c., of Bent Iron Plates."

III. To sanction the loan to the Committee for promoting the Exhibition of Musical Instruments at the South Kensington Museum, of such objects of that kind as the Council may think fit.

The following President, Council, and Officers, were elected for the year 1871-72.

PRESIDENT:

Rev. J. H. JELLETT, B. D.

COUNCIL:

Committee of Science.

W. K. Sullivan, Ph. D.
Henry Hennessy, F. R. S.
Rev. Samuel Haughton, M. D., F. R. S.
Robert McDonnell, M. D., F. R. S.
E. Perceval Wright, M. D.
Robert S. Ball, LL. D.
Sir Robert Kane, LL. D., F. R. S.
George J. Stoney, M. A., F. R. S.
William Archer, Esq.
David Moore, Ph. D.
John Casey, LL. D.

Committee of Public Literature and Antiquities.

John T. Gilbert, F. S. A.
William H. Hardinge, Esq.
John Kells Ingram, LL. D.
Sir W. R. Wilde, M. D.
Samuel Ferguson, LL. D.
W. J. O'Donnavan, LL. D.
Alexander G. Richey, LL. B.
John R. Garstin, LL. B., F. S. A.
Rev. William Reeves, D. D.
Lord Talbot De Malahide, F. R. S.

TREASURER.—John R. Garstin, LL. B.
SECRETARY OF THE ACADEMY.—W. K. Sullivan, Ph. D.
SECRETARY OF THE COUNCIL.—John Kells Ingram, LL. D.
SECRETARY OF FOREIGN CORRESPONDENCE.—Sir W. R. Wilde, M. D.
LIBRARIAN.—John T. Gilbert, F. S A.
CLERK TO THE ACADEMY.—Edward Clibborn, Esq.

The President, under his hand and seal, appointed the following Vice-Presidents for the ensuing year :—

Henry Hennessy, F. R. S.
Rev. Samuel Haughton, M. D., F. R. S.
Samuel Ferguson, LL. D.
Lord Talbot de Malahide, F. R. S.

"Christian Inscriptions in the Irish language," was presented to the Library by Miss Stokes, and thanks returned for the donation.

APRIL 8, 1872.

Rev. J. H. JELLETT, B. D., President, in the Chair.

William Hillier Baily, F. G. S., John Ball Greene, Esq., Sir Arthur Purves Phayre, K. C. S. I., and Standish G. Rowley Esq., were elected Members of the Academy.

The Secretary reported from the Council that Mr. Phineas Abraham had been obliged to give up his intended voyage, and had accordingly returned the £50 which had been voted to him for scientific researches connected therewith. He also explained that the Council had allocated this money as follows :—

£15 0 0	to Mr. A. G. More, in aid of his researches on the Flora of the West of Ireland.
£17 10 0	to Mr. Charles E. Burton, to construct a spectroscope, to investigate the Aurora Borealis, and Zodaical Light.
£17 10 0	to Mr G. J. Stoney, towards the completion of the Great Academy Spectroscope, in aid of his researches in the Interrupted Spectra of Gases, the original grant having been found insufficient.
£50 0 0	

The action of the Council was approved and ratified.

The following papers were read:—

"On the Constitution of the Outer Atmosphere of the Sun;" by G. J. Stoney, F. R. S.

"On the Floatation of Sand on the Surface of the River Ganges;" communicated by Professor Hennessy, for F. X. J. Webber, Esq.

The thanks of the Academy were voted to the Cavaliere Negri for his donation to the Library, and to the Cavaliere Cattaneo for the trouble he had taken in the matter.

April 22, 1872.

Rev. J. H. Jellett, B. D., President, in the Chair.

The following papers were read:—

"On the Anatomy of Chlamydophorus Truncatus and other Edentates;" by Professor Macalister.

"On some Evidence touching the Age of Rath-Caves;" by Samuel Ferguson, LL. D.

Donations to the Library were presented, and thanks voted to the several donors.

May 13, 1872.

Rev. J. H. Jellett, B. D., President, in the Chair.

Permission was granted to the Council to lend a picture of General Vallancey, and such objects from the Museum to the Dublin Exhibition of 1872, as shall seem best to them.

Read a letter from Rev. William Reeves, D. D., accompanying a donation of Charles H. Todd, LL. D., consisting of a collection of

papers, which embrace a large portion of the late Dr. J. O'Donovan's literary correspondence purchased by his brother the late Rev. J. Todd, D. D., Ex-president of the Academy.

The thanks of the Academy were voted to Dr. Todd for his valuable gift.

The following papers were read:

"On some Evidences of Connexion between the Early Populations of Asia and Central America;" by Samuel Ferguson, LL. D.

"On the Daily Weather Reports;" also

"On a Compound Prism of Bisulphide of Carbon and Glycerine;" by G. J. Stoney, F. R. S.

Donations of books were presented, and thanks voted to the several donors.

May 27, 1872.

Rev. J. H. Jellett, B. D., President, in the Chair.

On the recommendation of the Council the operation of By-law 5 of Chap. VIII. was suspended, it being understood, that "any member desirous of procuring a copy of the revised Statutes and By-laws" before the meeting of the Academy at which they should be considered, will be supplied with one on application.

The following paper was read by the Secretary for Hodder M. Westropp, Esq.—"On a Lantern or Fanal on St. Catherine's Down, Isle of Wight."

Donations to the Library were presented, and thanks voted to the several donors.

June 10, 1872

Henry Hennessy, F. R. S., Vice-President, in the Chair.

The following papers were read:—

"On Recent Additions to the Flora of Ireland;" by A. G. More, Esq.

"On a MS. alleged to have been written by St. Camin of Iniscaltra;" by W. M. Hennessy, Esq.

JUNE 24, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

Francis Nolan, Esq., and Thomas Baldwin, Esq., were elected Members of the Academy.

The Secretary of the Council brought up the revised edition of the By-laws, as recommended by the Council, which were unanimously adopted, and ordered to be inserted on the Minutes of the Academy.

The following papers were read:—

"On a New Form of Goriometer;" by J. P. O'Reilly, Esq., C. E.

"A Resumé of the Irish Mosses;" by David Moore, Ph. D.

"A New Determination of the Elements of the Orbit of the Binary Star ξ Ursae Majoris." And a supplement to his paper on the "Theory of Screws;" by Robert S. Ball, LL. D.

"On some Undescribed Antiquities in the Parishes of Killenny and Kilteale, Queen's County;" by Rev. John O'Hanlon.

"On Heat as a Factor in Vital Action;" by George Sigerson, M. D.

"On the Genus Tetrapedia (Reinsch)," and "On two new kindred Chroococcaceous Forms," and "On a Minute Nostoc;" by William Archer, Esq.

"On a Bronze Shield lately found in the Co. of Limerick;" by Maurice Lenihan, Esq.

Donations to the Library and Museum were presented, and thanks voted to the several donors.

The Treasurer presented the abstract of accounts for the year ended the 31st March, 1872, with the Auditor's report thereon (*see* next page); and also his estimate for the year 1872–73, as amended by the Council.

The Academy adjourned to Monday, 11th November, 1872.

ROYAL IRISH

GENERAL ABSTRACT OF THE ACCOUNT OF JOHN RIBTON

FROM 1st APRIL 1871,

RECEIPTS.	For Special Purposes. £ s. d.	For General Purposes. £ s. d.	Total of each Class. £ s. d.
Balance from last Year, Not appropriated, . .	. . .	205 18 0	
Balance from last Year, Mus. Cat. Sale, awaiting Investment (*invested as opposite*), . . .	0 14 4		206 12 4
From PARLIAMENTARY GRANTS:—			
Unappropriated:—"Old Grant," . . .	. . .	584 0 0	
Appropriated:—			
Preparation of Scientific Reports, . . .	200 0 0		
Library, ...	200 0 0		
Researches in connexion with Celtic Manuscripts, ...	200 0 0		
Museum, ...	200 0 0		
Purchase of Treasure Trove, ...	100 0 0		
Illustration and Printing of Transactions and Proceedings, ...	200 0 0		1684 0 0
„ MEMBERS' PAYMENTS:—			
Entrance Fees, ...	. . .	42 0 0	
Annual Subscriptions, ...	. . .	260 8 0	
Life Membership Compositions (*invested as opposite*), ...	96 12 0		399 0 0
„ PUBLICATIONS SOLD:—			
Transactions, ...	. . .	—	
Proceedings, ...	. . .	—	
Irish MSS. Series, ...	. . .	1 2 6	
Leabhar na h-Uidhri, ...	. . .	55 9 6	
Leabhar Breac, ...	. . .	—	
Museum Catalogue (*invested as opposite*), .	0 13 0		57 5 0
„ INTEREST ON INVESTMENTS:—			
Life Composition—Consol. Stock, . . .	. . .	57 15 8	
Cunningham Bequest—New 3 per cents. (*invested as opposite*), ...	67 0 4		
Museum Catalogue—Bank of Ireland Stock (*invested as opposite*), ...	2 14 0		127 10 0
„ Refunded Bank Commission for collecting country Cheques, ...	. . .	0 0 6	0 0 6
„ TEA FUND Subscriptions & Sale of Tickets,	9 17 0		9 17 0
£	1277 10 8	1206 14 2	2484 4 10

I certify that the above Account is correct, according to the best of my knowledge

For Auditor's Report,

ACADEMY.

GARSTIN, TREASURER OF THE ROYAL IRISH ACADEMY,

TO 31ST MARCH, 1872.

PAYMENTS.	From Funds appropriated for Special Purposes. £	s.	d.	From Funds available for General Purposes. £	s.	d.	Total of each Class. £	s.	d.
For SCIENTIFIC & LITERARY PURPOSES:—									
Polite Literature and Antiquity objects, .	. . . .			50	0	0			
Scientific Reports, ...	200	0	0						
Library, ...	200	0	0	93	8	8			
Irish Scribe, &c., ...	200	0	0						
,, (including Lithographing of Leabhar Breac), .	. . . .			156	9	3			
Museum, ...	200	0	0	50	0	0			
Treasure Trove, ...	100	0	0						
Transactions and Proceedings, ...	200	0	0						
,, ,, and Leabhar na h-Uidhri,	. . . .			107	11	7			
	1100	0	0	457	9	6			
							1557	9	6
,, **ESTABLISHMENT CHARGES:—**									
Salaries, ...	. . . .			344	0	0			
Wages and Liveries, ...	. . . .			172	9	5			
Furniture and Repairs, ...	. . . .			8	5	4			
Fuel, ...	. . . .			15	9	0			
Lighting, ...	. . . .			37	10	3			
Insurance, Taxes, and Law, ...	. . . .			10	7	10			
Stationery, ...	. . . .			4	2	0			
Printing (Miscellaneous), ...	. . . .			26	3	11			
Postage, ...	. . . .			15	6	9			
Freights, Incidentals, and Contingencies, .	. . . .			10	18	1			
Commission on Country Cheques (*refunded opposite*), ...	. . . .			0	0	6			
							639	13	1

,, **INVESTMENTS (CAPITAL):—**

	Stock Bought. £	s.	d	Description.	Total Stock. £	s.	d	From Funds appropriated for Special Purposes. £	s.	d.
Life Membership Compositions, .	103	16	8	Consol. Stock,	2079	5	8	96	12	0
Cunningham Bequest Interest,	73	6	0	New 3 per Cents,	2390	19	6	67	0	4
Museum Catalogue Produce, . . .	1	8	4	Bk. of Ir. Stock,	25	19	6			
Viz.:—Sales, 14*s*. 4*d*. + 13*s*. opposite, .					£1	7	4			
Produce of Stock, as opposite, .					2	14	0			
								4	1	4

	Special £	s.	d.	General £	s.	d.	Total £	s.	d.
(Investments)				. . .			167	13	8
TEA FUND Expenditure, ...	9	17	0	10	5	7	20	2	7
	1277	10	8	1107	8	2	2384	18	10
Balance to credit of the Academy, . . .	. . . .			99	6	0	99	6	0
£	1277	10	8	1206	14	2	2484	4	10

and belief, JOHN RIBTON GARSTIN, *Treasurer, R. I. A.*

see next page.

AUDITORS' REPORT.

We have examined the above General Abstract, and compared the Vouchers for the details of the several heads thereof, and find the same to be correct, leaving a Balance of ninety-nine pounds and six shillings (£99 6*s*. 0*d*.) to the credit of the Academy; which amount is certified by the Accountant-General to have remained to the credit of the Academy's account in the Bank of Ireland on the 30th of March, 1872.

The Treasurer has also exhibited to us a like Certificate in respect of the invested CAPITAL, showing that the amounts of Stock standing in the name of the Academy on the 1st of April, 1872, were £2390 19*s*. 6*d*. New 3 per cents.; £2079 5*s*. 8*d*. Consols; and £25 19*s*. 6*d*. Bank of Ireland Stock.

(Signed) WILLIAM ARCHER, M. H. CLOSE, } *Auditors.*

June 3, 1872.

APPENDIX.

ABSTRACT OF THE

MINUTES OF THE ACADEMY

FOR THE SESSION 1872–73.

NOVEMBER 11, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"On ancient Historic Tales in the Irish language;" by Brian O'Looney, Esq. He also submitted translations of a number of Irish Tales.

"On an Ogham Inscription;" by the Right Rev. the Lord Bishop of Limerick, communicated through Samuel Ferguson, LL. D., V. P.

The Secretary, on the part of Rev. Maxwell Close, presented a transcript of the late E. O'Curry's Catalologue of the Irish MSS. in the British Museum, and proposed a vote of thanks to the donor, which was carried by acclamation. Donations to the Library were presented, and thanks voted to the several donors.

STATED MEETING, NOVEMBER 30, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"On some paper casts of ancient Inscriptions in the counties of Galway and Mayo;" by Richard Burchett, Esq.; communicated by Samuel Ferguson, LL. D., V. P.

"On the time and topography of the Bruighean Da Choga;" by Denis H. Kelly, Esq.

"On a fragment of an ancient Crozier head, in the collection of the Rev. James O'Laverty;" by John Ribton Garstin, F. S. A.

The following donations to the Museum were presented, and thanks voted to the several donors:—

Two Cinerary Urns, found in a mound in the parish of Ballyhayne,

county Meath; presented by J. Tisdall, Esq., through A. R. Nugent, Esq., M. R. I. A.

Two Bronze Roman Medallions, presented by Mr. Baker, through W. Sweetman, Esq., M. R. I. A.

A Flint Arrow Head; presented by Mr. Doherty, of Buncrana.

Donations to the Library were presented, and thanks voted therefor.

DECEMBER 9, 1872.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"On the Ammonia present in Fungi;" by W. K. Sullivan, Ph. D.

"On the Dyeing Materials and Processes of the Ancient Irish;" by W. K. Sullivan, Ph. D.

Donations to the Library were presented, and thanks voted therefor.

JANUARY 13, 1873.

REV. J. H. JELLETT, B. D., President, in the Chair.

Lord Castletown of Upper Ossory; Arthur Andrews, Esq.; Thomas Drew, Esq.; J. S. W. Durham, Esq.; Very Rev. John Farrell; Lieutenant-Colonel J. F. Hickie; Rev. C. M'Cready; Joseph Nolan, Esq.; Alexander Porter, M. D.; G. D. Powell, M. D.; Evelyn P. Shirley, Esq., F. S. A.; P. J. Smyth, Esq., Ch. L. H., M. P.; and Robert E. Ward, Esq., D. L., were elected Members of the Academy.

The following Papers were read:—

"On the Contents of the Book of Leinster;" by B. O'Looney, Esq.

"On a species of the Labyrinthodont Amphibia, from Garrow Colliery;" by W. H. Baily, Esq.

Donations to the Museum were presented, and thanks returned to the several donors.

JANUARY 27, 1873.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"First Report on Hyalonema Mirabilis;" by Dr. E. P. Wright.

"On an Ancient Crucifix Figure;" by Sir W. R. Wilde, M. D.

The following donations to the Museum were presented:—

Two ancient Bronze Swords, found near Maguire's Bridge; by the Earl of Enniskillen; a sheet of Drawings of Antiquities; by Marc Pontet, Esq. The thanks of the Academy were voted to the donors.

It was moved by Sir W. R. Wilde, M. D., and seconded by David R. Pigot, Esq., and Resolved—

That it be referred to Council to consider and procure Reports upon the best means of the utilization of Peat, as fuel in Ireland.

FEBRUARY 10, 1873.

REV. J. H. JELLETT, B. D., President, in the Chair.

W. H. Patterson, Esq., and T. A. Readwin, Esq., were elected Members of the Academy.

The following Paper was read:—

"On the Callan Mountain Inscription;" by S. Ferguson, LL. D., V. P.

FEBRUARY 24, 1873.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Papers were read:—

"On Sugar Beet grown in Ireland, in the year 1872;" by the President.

"On some Clay, Iron, and Bronze Pipes;" and also "a Charter of James II.;" by W. J. O'Donnavan, LL. D.

Donations to the Museum and Library were presented, and thanks voted to the donors.

STATED MEETING, MARCH 15, 1873.

REV. J. H. JELLETT, B. D., President, in the Chair.

The following Report of the Council was read and adopted:—

REPORT OF THE COUNCIL, FOR THE YEAR 1872-3.

SINCE our last Report was presented to the Academy, the following papers have been published in our Transactions: In Science:—

1. "On Muscular Anomalies in Human Anatomy." By Professor A. Macalister, M. B.

2. "Account of Experiments on the Retardation experienced by Vortex Rings, when moving through Air." By Professor R. S. Ball, LL. D.

3. "A Geometrical Study of the Kinematics: Equilibrium, and small Oscillations of a Rigid Body." By Professor R. S. Ball, LL. D.

And the following paper is in the press:—

"A Monograph on the Anatomy of Chlamydophorus Truncatus, with Notes on the Structure of other Species of Edentata." By Professor Macalister, M. B.

In Polite Literature and Antiquities, the following papers are in the press: —

1. "On an Ancient Chalice and Brooches lately found at Ardagh, in the county of Limerick." By the late Earl of Dunraven.

2. "On the Felire of Oengus." By Whitley Stokes, LL. D.

Parts 5 and 6 of Volume I. of the New Series of our Proceedings have also appeared; and Parts 7 and 8 are in the press.

Papers have been read before the Academy during the past year:—

In the department of Science—By the President; Professor R. S. Ball, LL. D.; G. J. Stoney, F. R. S.; Professor H. Hennessy F. R. S.; Professor W. K. Sullivan, Ph. D.; Professor A. Macalister, M. B.; Professor E. P. Wright, M.D.; Professor J. P. O'Reilly; Mr. F. X. J. Webber; Mr. W. Archer; Mr. W. H. Baily; David Moore, Ph. D.; Professor G. Sigerson, M. D.; and Mr. Alexander G. More.

In the department of Polite Literature and Antiquities—By the Lord Bishop of Limerick; Samuel Ferguson, LL. D.; Mr. D. H. Kelly; Rev. J. O'Hanlon; Sir W. Wilde; Professor W. K. Sullivan, Ph. D.; Mr. W. M. Hennessy; W. J. O'Donnavan, LL. D.; Mr. Brian O'Looney; Mr. H. M. Westropp; Mr. J. R. Garstin; and Mr. M. Lenihan.

The price of the Bell and Bell-shrine of St. Patrick having been completed by the sum provided in the Parliamentary Estimates of last year, these valuable objects have been finally secured for our Museum.

In pursuance of a Resolution passed at the Stated Meeting of the Academy in March last, the Council have purchased Dr. Aquilla Smith's collection of Irish Coins and Tokens.

The transfer of the collection of Antiquities to their new places of deposit has been continued during the year. The Bronze objects, as enumerated and arranged in the Catalogue, have all, with some trifling exceptions, been removed to the Glass Cases in the Long Room, in conformity with the plan prescribed by the Museum Committee. The entire range of presses on the north side of this apartment is now complete, and presents an appearance highly creditable to the taste and ability of the Curator. The Smith collection of Coins has been deposited in the Rail Cases in the Gallery. The crypt under the Library, which, owing to its darkness and want of ventilation, had for many years served only as a lumber room, has undergone extensive changes by which light and air are now admitted, and has been converted into a Lapidary Museum. Here are deposited on iron stands the twelve ogham-inscribed stones which formed the Academy's original collection of this class of objects. Ten additional ogham-inscribed stones have during the past year been acquired by the Academy by purchase from the representatives of the late Mr. Windele of Cork, and are also deposited in the crypt. Iron stands for these have been ordered and are

in preparation. The miscellaneous collection of sculptured stones, formerly heaped on the floor, has been arranged and built into dwarf-walls dividing the south side of the crypt into four bays or compartments: the sculptured faces form the wall-surfaces, and are now seen to advantage. On the north side the position of the framework supporting the collection of ancient Canoes has been altered so as to allow access to the north wall of the crypt, on which are now ranged the casts and moulds from ancient crosses and other monumental objects. When proper arrangements shall have been made for heating, and improving the approach to, this apartment, it is expected that it will constitute a valuable and very interesting addition to the general Museum.

Besides the Windele collection of ogham-inscribed monuments, the Academy has acquired during the year a fine bronze shield, which will be described in the forthcoming number of the Proceedings, and also several additions to its miscellaneous Irish antiquities.

In laying before the Government the usual annual statement of the requirements of the Academy, we thought it right to repeat our action of last year by appending to the ordinary estimate several supplementary items. These are as follows:—For the cost of attendance and general expenses necessary in order fully to open to the public our Museum Collections, £200; for the publication of materials prepared by aid of the grant for Researches in connexion with Celtic Manuscripts, £200; to complete the price of the Smith Collection of Coins, £81 8*s*. 7*d*.; and for the purchase of the Ardagh Chalice and Brooches, £500. The last of these amounts was fixed in consequence of an offer made to us by the Right Rev. Bishop Butler to sell the objects referred to, to the Academy, for the sum named, which the Museum Committee reported to be a reasonable price. When that offer reached us, we at once resolved, without waiting for the result of our application to the Government, to recommend to the Academy the purchase of the Chalice and Brooches, and to request from you the same discretion as to the financial arrangements which would be necessary for the purpose, as you accorded us in the case of the Smith Collection of Coins. But, when just about to adopt this course, we were informed that a controversy had arisen respecting the ownership of these objects, and that the question whether they came under the description of Treasure Trove was under the consideration of Her Majesty's Government. In the discussion of these matters we have remained entirely neutral, but we have been obliged to suspend our action for the purchase of the Chalice and Brooches until some decision is arrived at respecting them.

The first part of the lithograph edition of Leabhar Breac has been issued, and received with general satisfaction. The second part, completing the work, is in active progress, and will, we trust, be published within a few months. Every effort has been made to ensure perfect accuracy; and each page, before being printed off, is most carefully examined by Mr. O'Longan and Mr. O'Looney. An arrangement has been entered into for the production of a facsimile copy of the Book

of Leinster by the joint action of the Academy and of Trinity College, to which latter body the manuscript belongs. This announcement will be received with much gratification, as it has long been desired that the contents of this valuable collection of ancient Irish pieces should be made generally available to those who are interested in such researches.

The catalogue of our Irish Manuscripts has been continued. A Register of the Library has been commenced, and a considerable portion of it is already completed. Among the additions to our Library during the past year, we may specially mention the Ordnance Survey of the Peninsula of Sinai, presented by Her Majesty's Government; and a copy of the late Professor O'Curry's Catalogue of the Irish Manuscripts in the British Museum, for which we are indebted to the liberality of our fellow-member, the Rev. Maxwell Close. We have also obtained, by application to the Commissioners for the publication of the Ancient Laws and Institutes of Ireland, a copy of seventeen volumes of the transcript of the Brehon Laws, made for the Commissioners by the late Dr. O'Donovan and Professor O'Curry. Every facility consistent with the rules of the Academy is afforded in the Library to persons who desire to consult our collections whether of printed books or of manuscripts.

It was mentioned in our last Report that steps were in progress for preparing a revised code of the Statutes and By-laws of the Academy. Such a code has since been completed and submitted to you, and has received your assent. It is believed that the effect of the revision has been to remove a number of inconsistencies and ambiguities, and to bring the whole of our Laws and Regulations for the first time into a complete, harmonious, and intelligible form.

The list of Council, Officers, and Members, which had not been printed since 1866, has undergone a complete revision, and has been issued to members within the past year. It appears from it that the number of our Members on the 1st December 1872, was as follows:—Life Members, 200; Annual Members, 150; and Honorary Members, 50, making a total of 400.

The Council have reason to anticipate that the Treasurer's Report, when presented—as usual after the close of the present month—will show a highly satisfactory state of the Academy's finances.

The existing regulations respecting Medals and Premiums to be given out of the interest of the Cunningham Fund not having been found to work satisfactorily, have been repealed, so that awards can for the future be made from it as may be thought expedient, or as fitting occasion may arise, subject to no restriction except those imposed by the will of the testator. The first use the Council have made of the freedom of action thus recovered has been one which they believe will meet with the unanimous approval of the Academy—namely, to award a Cunningham Medal to Sir William Wilde, as a permanent mark of the Academy's appreciation of his labours in connexion with the Catalogue of the Museum. The Council have also resolved to offer, out of the same fund, four Premiums, of Fifty Pounds

each, for Essays on the Irish Language, and the Literature in that Language, written and un-written, in each province of Ireland. They propose inviting, in the first instance, Essays relative to the Irish Language in the provinces of Munster and Connaught. The Council will take care to make it known that they do not undertake to award any Premium unless they shall consider the Essays sent in to possess adequate merit.

A Bill for the preservation of Ancient National Monuments in the United Kingdom, having been prepared by Sir John Lubbock, was submitted by him to the Council, with a request that they would supply a list of such Irish monuments as ought, in their opinion, to be enumerated in the Schedule. The Council, having been informed that a Bill for the same purpose, intended to apply to Ireland only, had been prepared by Mr. P. J. Smyth, M. P., obtained a copy of it also; and requested the Committee of Polite Literature and Antiquities to consider both Bills, and to report as to any clauses in either of them which were open to objection, and as to the additional provisions which might seem necessary to make an efficient measure. The Committee was further requested to prepare such a list of Irish monuments as Sir John Lubbock desired. This list was accordingly drawn up and sent to Sir John Lubbock, and a copy of it was also placed at Mr. P. J. Smyth's disposal. The Report of the Committee on the two Bills contains a very full examination of the merits and defects of the proposed measure; and a copy of this Report has been forwarded to Sir John Lubbock. We have also, at his request, presented a petition to the House of Commons in favour of his Bill, praying, however, at the same time, that it may be amended by introducing provisions for an enlarged representation of Ireland on the Board of Commissioners which it proposes to create, as well as for the holding of meetings of this Board from time to time in Ireland.

After the Report of last year was presented, the Committee of Science, finding that Mr. Abraham, to whom a grant of £50 had been made, out of the sum of £200 annually placed at the disposal of the Academy for the assistance of scientific researches, was unable to avail himself of it, allocated this amount as follows:—

1. To Mr. Alexander G. More, £15, for Researches on the Flora of the West of Ireland.

2. To Mr. Charles W. Burton, £17 10*s.*, for the construction of a Spectroscope to investigate the Aurora Borealis and Zodiacal Light.

3. To Mr. G. J. Stoney, £17 10*s.*, towards the completion of the great Academy Spectroscope, to be used in that gentleman's Researches on the Interrupted Spectra of Gases, the original grant for this purpose having been insufficient.

The action of the Committee in making this allocation was approved by the Council, and their Resolution to that effect was reported to the Academy.

You will be asked at the present Meeting, to confirm the following grants, which have been made out of the same fund for the current year:—

1. To Mr. Wm. Hellier Baily, £50, in aid of additional Explorations at Kiltorcan, for Fossil Plants; subject to the condition that the fossils discovered shall be at the disposal of the Council of the Academy.

2. To Mr. G. H. Kinahan, £40, for Microscopic Examination of Igneous Rocks.

3. To Professor M'Nab, £30, for Researches in Vegetable Physiology and Histology.

It will be proposed to the Academy to allocate the remaining portion (£80) of the fund to the illustration of the special reports on Science, which are in course of preparation.

Mr. Clibborn having resigned the offices of Museum Curator, Assistant Librarian, Serjeant at Mace, and Resident Housekeeper, it was resolved to combine the last of these offices with that of Museum Clerk, which had a short time before become vacant; and out of a large number of candidates, a gentleman was selected for the appointment, who appeared to the Council to unite the qualifications of Antiquarian knowledge and executive ability. It is the duty of this officer to reside in the house, to have the charge of it, and of the collections it contains, to supervise the servants, to have the special custody of, and be responsible for, the articles in the Museum, and to act generally under the direction of the Council and the Museum Committee. Under this new arrangement, Mr. Clibborn, ceasing to reside in the house, continues to hold the office of Clerk of the Academy and Assistant Secretary, which he has so long filled with credit to himself and advantage to the institution.

Twenty-one Members have been elected during the year:—

1. Wm. Hellier Baily, Esq.
2. John Ball Greene, Esq.
3. Major-General Sir A. P. Phayre, K. C. S. I.
4. Standish G. Rowley, Esq.
5. Francis Nolan, Esq.
6. Thomas Baldwin, Esq.
7. Lord Castletown of Upper Ossory.
8. Arthur Andrews, Esq.
9. Thomas Drew, Esq., R. H. A., F. R. I. A. I.
10. J. S. W. Durham, Esq., F. R. G. S. I.
11. Very Rev. Canon Farrell.
12. Lieutenant-Colonel J. F. Hickie.
13. Rev. Christopher Mc Cready, M. A.
14. Joseph Nolan, Esq.
15. A. Porter, Esq., M. D.
16. George D. Powell, Esq., M. B.
17. Evelyn Philip Shirley, Esq., F. S. A., D. L.
18. P. J. Smyth, Esq., M. P.
19. R. E. Ward, Esq.
20. William Hugh Patterson, Esq.
21. T. A. Readwin, Esq., F. G. S.

The Academy has lost by death within the year four Ordinary Members, viz.:—

Edward Barnes, Esq., elected May 10, 1847.
Michael Merriman, Esq., elected April 8, 1867.
Thomas E. Beatty, M. D., elected June 24, 1833.
David Charles La Touche, Esq., elected November 23, 1835.

And four Honorary Members, viz.:—

Rev. Canon Adam Sedgwick, F. R. S., &c.
Mrs. Mary Somerville.
Colonel W. H. Sykes, F. R. S., &c.
Sir Frederick Madden, K. H., F. R. S., &c.

The Recommendation of the Council of the 8th of March, 1873, to allocate the following sums, out of the Grant for Scientific Researches, was adopted:—

£50 to William H. Baily, Esq., for additional Explorations at Kiltorcan, for Fossil Plants.

£40 to G. H. Kinahan, Esq., for the Microscopical Examinations of Rocks.

£30 to W. R. M'Nab, Esq., for Researches in Vegetable Physiology.

£80 to be allocated to the illustration of the special Reports on Science, which are in course of preparation.

The following President, Council, and Officers were elected for the year 1873:—

PRESIDENT:

Rev. J. H. JELLETT, B. D.

COUNCIL:

Committee of Science.

W. K. Sullivan, Ph. D.
Henry Hennessy, F. R. S.
Rev. Samuel Haughton, M. D.
Robert McDonnell, M. D., F. R. S.
E. Perceval Wright, M. D.
Robert S. Ball, LL. D.
Sir Robert Kane, LL. D., F. R. S.
William Archer, Esq.
David Moore, Ph. D.
John Casey, LL. D.
Thomas Hayden, L. R. C. S. I.

Committee of Polite Literature and Antiquities.

John T. Gilbert, F. S. A.
John Kells Ingram, LL. D.
Sir W. R. Wilde, M. D.
Samuel Ferguson, LL. D.

W. J. O'Donnavan, LL. D.
Alexander G. Richey, LL. D.
John R. Garstin, LL. B., F. S. A.
Rev. William Reeves, D. D.
Lord Talbot de Malahide, F. R. S.
Rev. Thaddeus O'Mahony, M. A.

TREASURER.—John Ribton Garstin, LL. B., F. S. A.
SECRETARY OF THE ACADEMY.—W. K. Sullivan, Ph. D.
SECRETARY OF THE COUNCIL.—John Kells Ingram, LL. D.
SECRETARY OF FOREIGN CORRESPONDENCE.—Sir W. R. Wilde, M. D.
LIBRARIAN.—John T. Gilbert, F. S. A.
CLERK OF THE ACADEMY.—Edward Clibborn, Esq.

The President, under his hand and seal, appointed the following Members of the Council for the ensuing year

VICE-PRESIDENTS.

Rev. Samuel Haughton, M. D., F. R. S.
Sir Robert Kane, LL. D., F. R. S.
Samuel Ferguson, LL. D.
Lord Talbot de Malahide, F. S. A., F. R. S.

The following gentlemen were elected Honorary Members of the Academy :—

In the Department of Science.

John C. Adams, F. R. S., &c., Cambridge.
Arthur Cayley, Cambridge.
James Dwight Dana, Yale College, U. S.
August W. Hofman, Berlin.
Wilhelm P. Schimper, Strasburg.
Padre Angelo Secchi, Rome.
George G. Stokes, F. R. S., Cambridge.

In the Department of Polite Literature and Antiquities.

Henry Wadsworth Longfellow, Cambridge, Mass.
His Excellency Cavaliero Costantino Nigra, Paris.
Rt. Hon. John, Baron Romilly, London.
John Obadiah Westwood, Esq., Oxford.

The President presented to Sir Wm. R. Wilde, M. D., the Cunningham Medal, awarded him by the Council "in appreciation of his labours in connexion with the Catalogue of the Museum."

APRIL 14, 1873.

WILLIAM STOKES, M. D., F. R. S., in the Chair.

Dr. Michael A. Boyd; John Frost, Esq.; Professor Alexander Macalister, M. B.; Major-General William James Smyth, R. A., F. R. S.; and Thomas Wilkinson, Esq., were elected Members of the Academy.

The following Papers were read:—

"Notes on Applied Mechanics, Nos. III., IV., and V.;" by Robert S. Ball, LL. D.

"On a Comparable Self-registering Hygrometer;" by Michael Donovan, Esq.

"On an Ogham-inscribed Pillar Stone lately discovered in the County Cork;" by Richard R. Brash, M. R. I. A.

Donations to the Library were announced, and thanks voted to the donors.

APRIL 28, 1873.

REV. WILLIAM REEVES, D. D., in the Chair.

The following Papers were read:—

"On Evidences of Sun-worship at Mount Callan;" by Samuel Ferguson, LL. D., V. P.

"A description of an Instrument for Keeping up Artificial Respiration (being a preliminary Report on the Innervation of the Heart);" by Dr. Nicholas Furlong.

Donations were announced, and thanks voted to the donors.

MAY 12, 1873.

REV. J. H. JELLETT, B. D., President, in the Chair.

The Right Hon. Chichester Fortescue, M. P., President of the Board of Trade, was elected a Member of the Academy.

The following Papers were read:—

"On the Influence of Dolomite on the Deposition of Carbonates and Silicates of Zinc, especially as illustrated by the Zinc Deposits of Silver Mines in the County of Tipperary;" by Professors Sullivan and O'Reilly.

"On Sepulchral Slabs in the County Donegal;" by W. H. Patterson, Esq., M. R. I. A.

Donations were announced, and thanks voted to the several donors.

The Treasurer laid on the table his Estimate for the year 1873-4, as approved by the Council; and submitted the Abstract of Accounts for 1872-3, with Auditors' Report thereon, as annexed:—

ROYAL IRISH

GENERAL ABSTRACT OF THE ACCOUNT OF JOHN RIBTON

FROM 1st APRIL, 1872,

RECEIPTS.	For Special Purposes. £ s. d.	For General Purposes. £ s. d.	Total of each Class. £ s. d.
Balance from last Year,	. . .	99 6 0	99 6 0
From PARLIAMENTARY GRANTS:—			
Unappropriated:—"Old Grant,"	. . .	584 0 0	
Appropriated:—			
Preparation of Scientific Reports,	200 0 0		
Library,	200 0 0		
Researches in connexion with Celtic Manuscripts,	200 0 0		
Museum,	200 0 0		
Purchase of Treasure Trove,	100 0 0		
Illustration and Printing of Transactions and Proceedings,	200 0 0		
Do. Special: — To complete the purchase of the Bell and Bell-shrine of St. Patrick,	193 0 0		
			1877 0 0
„ MEMBERS' PAYMENTS:—			
Entrance Fees,	. . .	110 5 0	
Annual Subscriptions,	. . .	327 12 0	
Life Membership Compositions (*invested as opposite*),	85 1 0		
			522 18 0
„ PUBLICATIONS SOLD:—			
Transactions,	. . .	14 0 2	
Proceedings,	. . .	0 16 4	
Irish MSS. Series,	. . .	2 0 7	
Leabhar na h-Uidhri,	. . .	56 8 0	
Leabhar Breac,	. . .	99 11 0	
Museum Catalogue (*invested as opposite*),	9 13 11		
			182 10 0
„ INTEREST ON INVESTMENTS:—			
Life Composition—Consol. Stock,	. . .	61 6 8	
Cunningham Bequest—New 3 per cents. (*see opposite*),	69 3 3		
Museum Catalogue—Bank of Ireland Stock (*see opposite*),	3 4 11		
			133 14 10
„ TEA FUND Subscriptions & Sale of Tickets,	10 10 6		10 10 6
£	1470 13 7	1355 5 9	2825 19 4

I certify that the above Account is correct, according to the best of my

For Auditors' Report

ACADEMY.

GARSTIN, TREASURER OF THE ROYAL IRISH ACADEMY,

TO 31st MARCH, 1873.

PAYMENTS.	Stock Bought	Description	Total Stock	From Funds appropriated for Special Purposes.	From Funds available for General Purposes.	Total of each Class.
For SCIENTIFIC & LITERARY PURPOSES:—				£ s. d.	£ s. d.	£ s. d.
Polite Literature and Antiquity objects,				. . .	. . .	
Scientific Reports,				200 0 0		
Library,				200 0 0	112 4 8	
Irish Scribe, &c.,				200 0 0		
„ (including Lithographing of Leabhar Breac),				. . .	188 8 4	
Museum,				200 0 0	24 14 2	
„ (special), to complete the purchase of the Bell and Bell-shrine of St. Patrick,				193 0 0		
Treasure Trove,				100 0 0		
Transactions and Proceedings,				200 0 0		
„ „ and Leabhar na h-Uidhri,				. . .	11 1 8	
				1293 0 0	336 8 10	
„ Cunningham Medal for Sir William Wilde,				21 0 0		
						1650 8 10
„ ESTABLISHMENT CHARGES:—						
Salaries,				. . .	372 1 3	
Wages and Liveries,				. . .	185 3 9	
Furniture and Repairs,				. . .	20 3 10	
Fuel,				. . .	98 12 0	
Lighting,				. . .	37 6 11	
Insurance, Taxes, and Law,				. . .	27 9 8	
Stationery,				. . .	22 5 10	
Printing (Miscellaneous),				. . .	43 0 2	
Postage,				. . .	16 19 7	
Freights, Incidentals, and Contingencies,				. . .	81 10 0	854 13 0
„ INVESTMENTS (CAPITAL):—	£ s. d.		£ s. d.			
Life Membership Compositions,	91 10 11	Consol. Stock,	2170 16 7	85 1 0		
Cunningham Bequest Interest, balance,	52 10 7	New 3 per Cents,	2443 10 1	48 3 3		
Museum Catalogue Produce, as opposite, (except 8d carried forward),	4 6 0	Bk. of Ir. Stock,	50 5 6	12 18 2		146 2 5
TEA FUND Expenditure,				10 10 6	10 6 7	20 17 1
				1470 12 11	1201 8 5	2672 1 4
Balance to credit of the Academy, Unappropriated,				. . .	153 17 4	
Balance to credit of the Academy, Appropriated (Mus. Catalogue Sale balance),				0 0 8		153 18 0
				£1470 13 7	1355 5 9	2825 19 4

knowledge and belief, JOHN RIBTON GARSTIN, *Treasurer, R. I. A.*

see next page.

AUDITORS' REPORT.

We have examined the above General Abstract, and compared the Vouchers for the details of the several heads thereof, and find the same to be correct, leaving a Balance of One Hundred and Fifty-three Pounds and Eighteen Shillings to the credit of the Academy; which amount (with £81 8*s.* 7*d.*, then undrawn) is certified by the Accountant-General to have remained to the credit of the Academy's account in the Bank of Ireland on the 1st of April, 1873.

The Treasurer has also exhibited to us a like Certificate in respect of the invested *Capital*, showing that the amounts of Stock standing in the name of the Academy on the same day were £2443 10*s.* 1*d.*, New Three per cents. ; £2170 16*s.* 7*d.*, Consols; and £25 19*s.* 6*d.*, Bank of Ireland Stock (besides transfer-certificate for £4 6*s.* of the same, the purchase of which was not completed until after the 1st of April).

(Signed) William Archer, M. H. Close, } *Auditors.*

May, 1873.

Fig. 1.

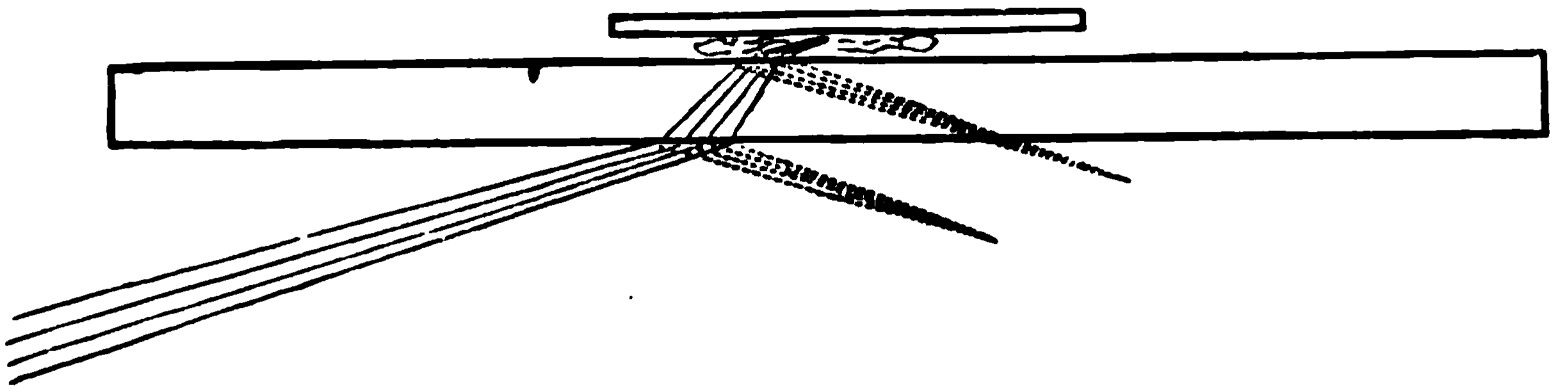


Fig. 2.

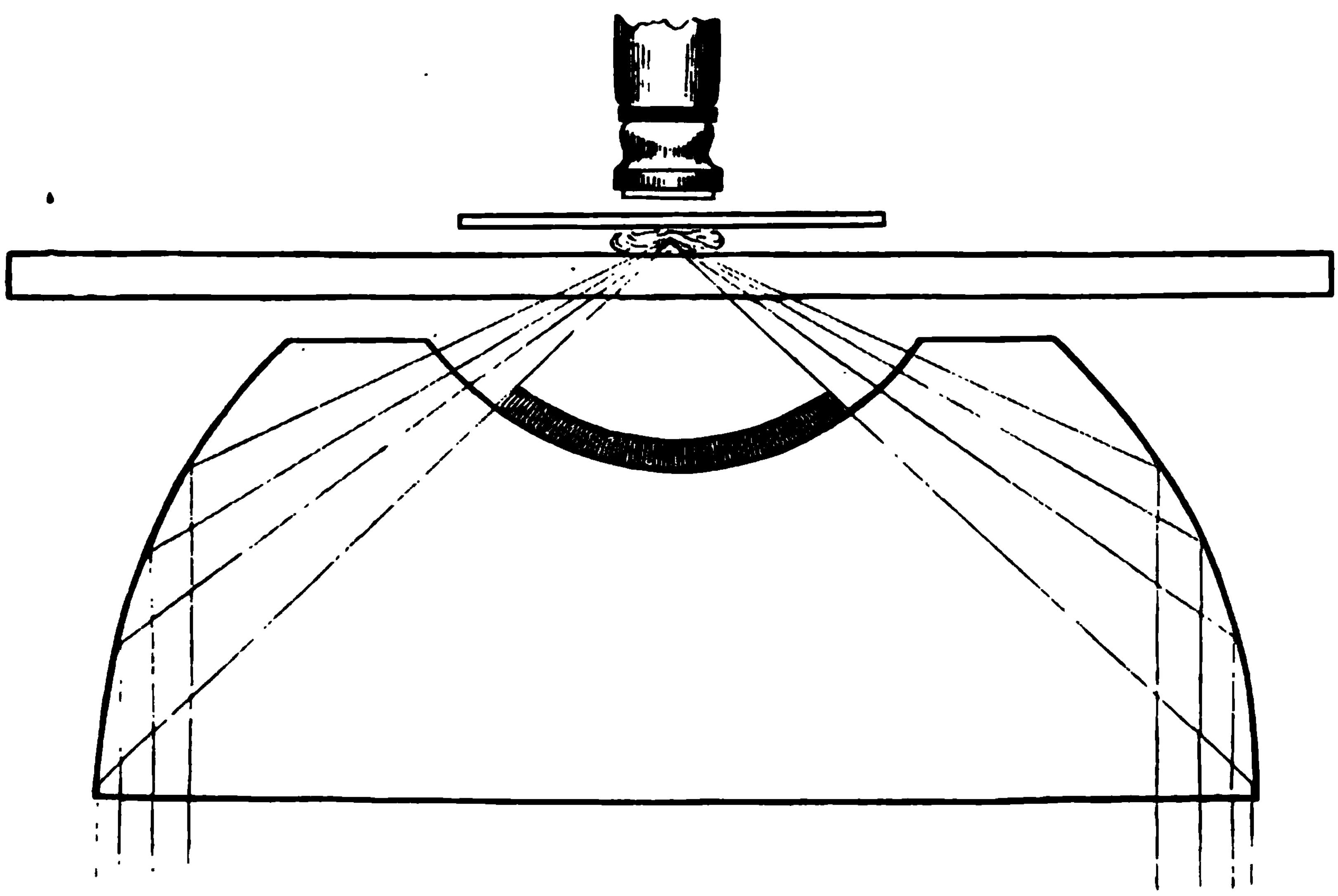
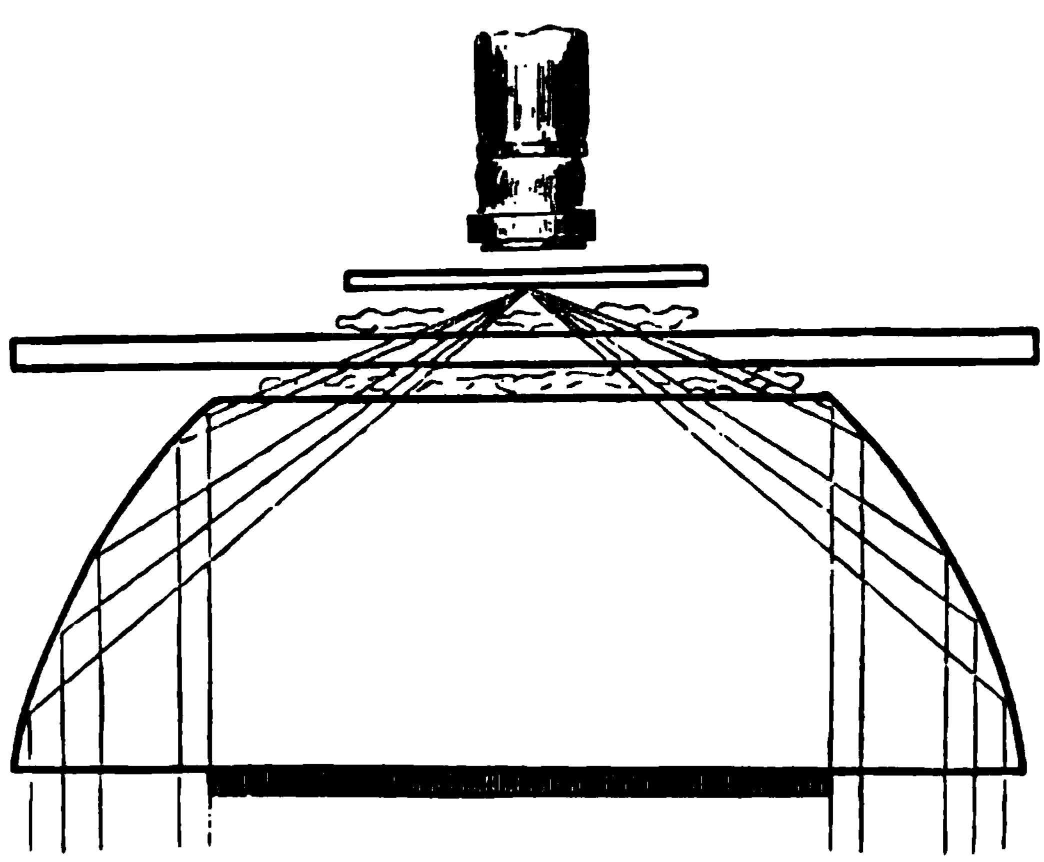


Fig. 3.



Dr. Barker on the Illumination of Microscopic Objects.

Fig. 1.

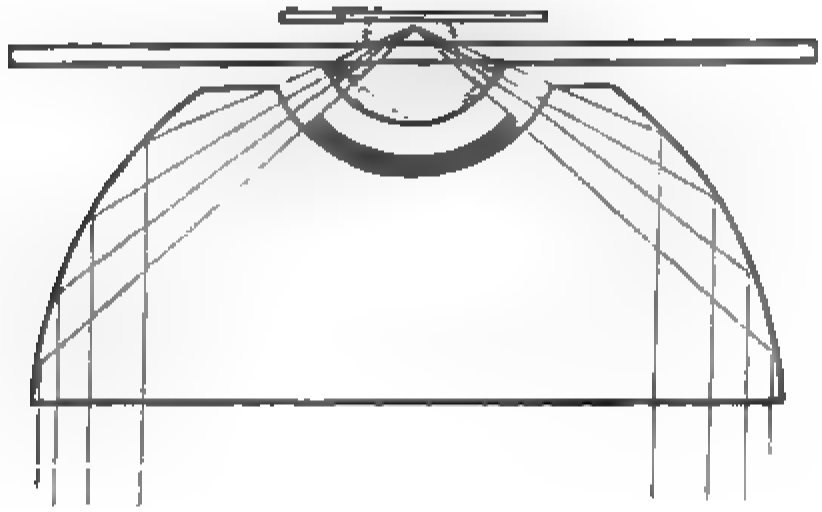
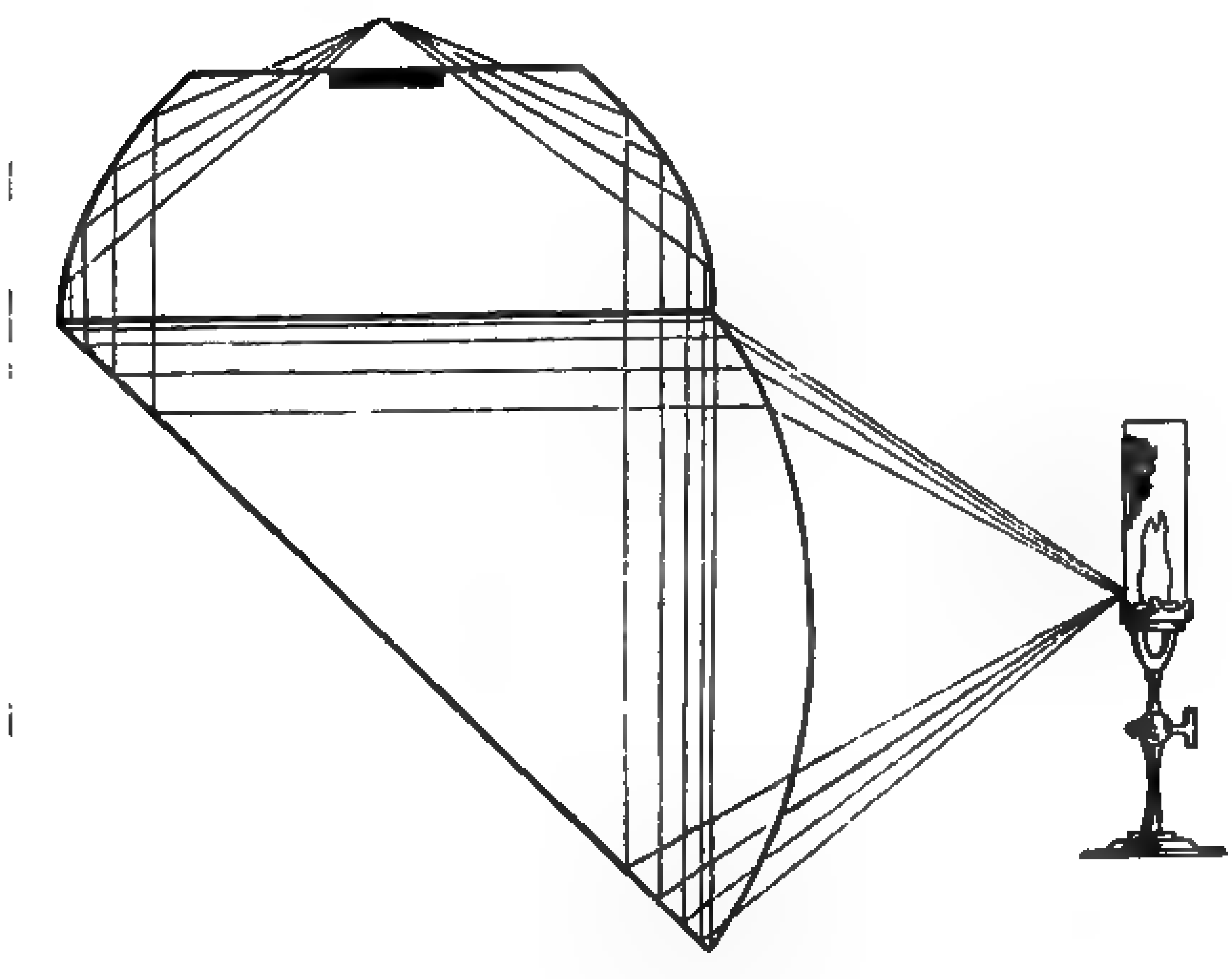


Fig. 2.



DR. BARKER on the Illumination of Microscopic Objects.

Fig. 1.

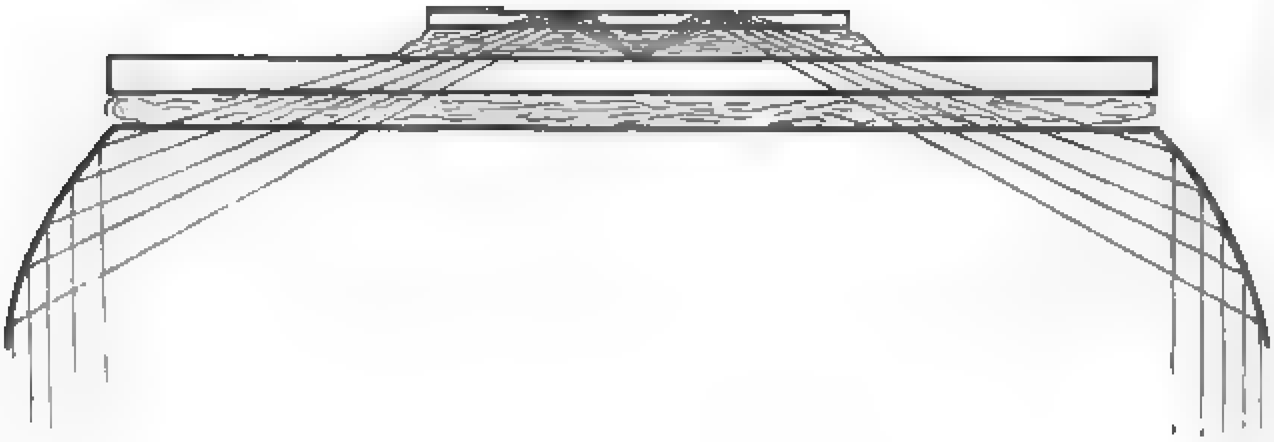
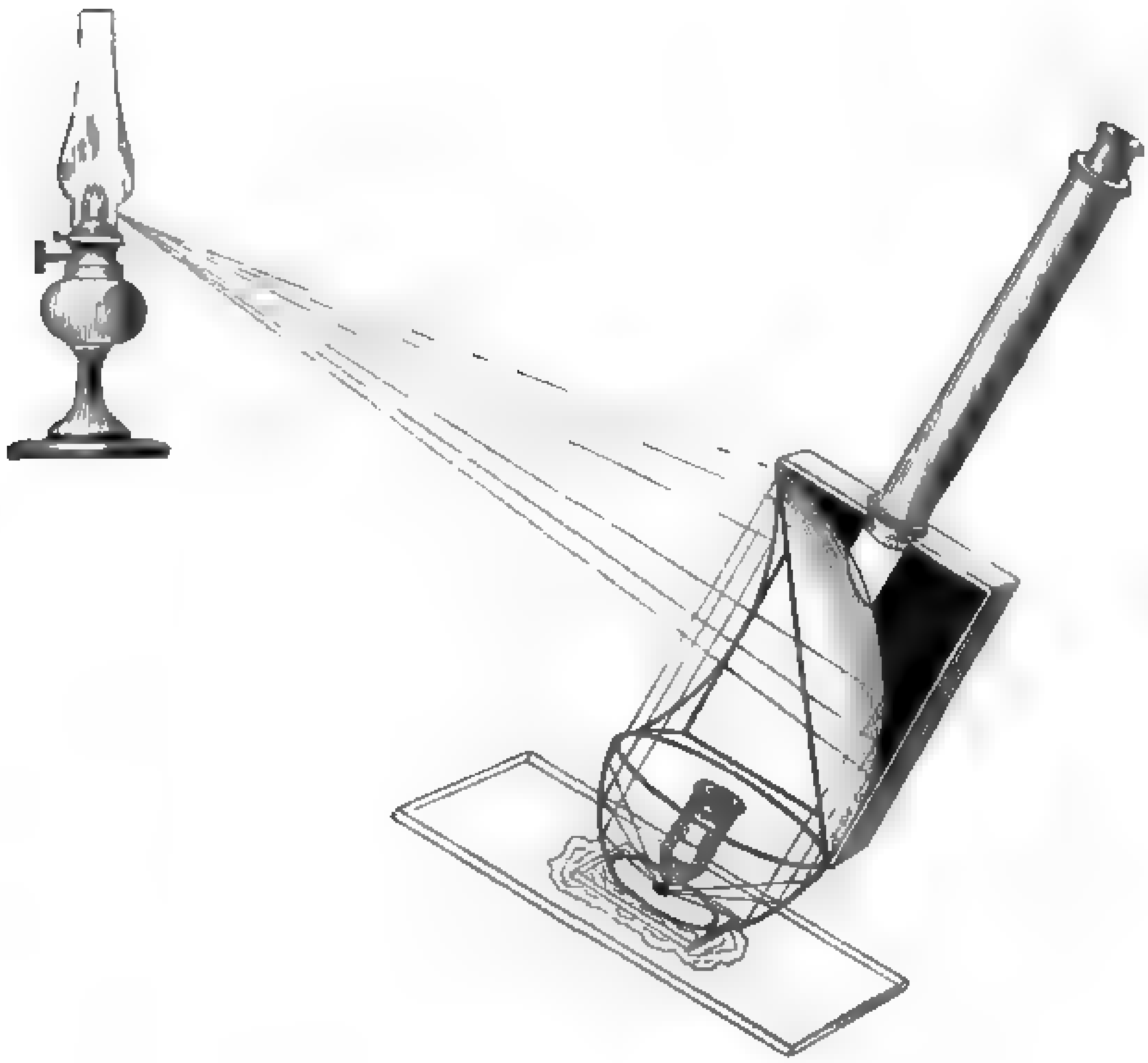
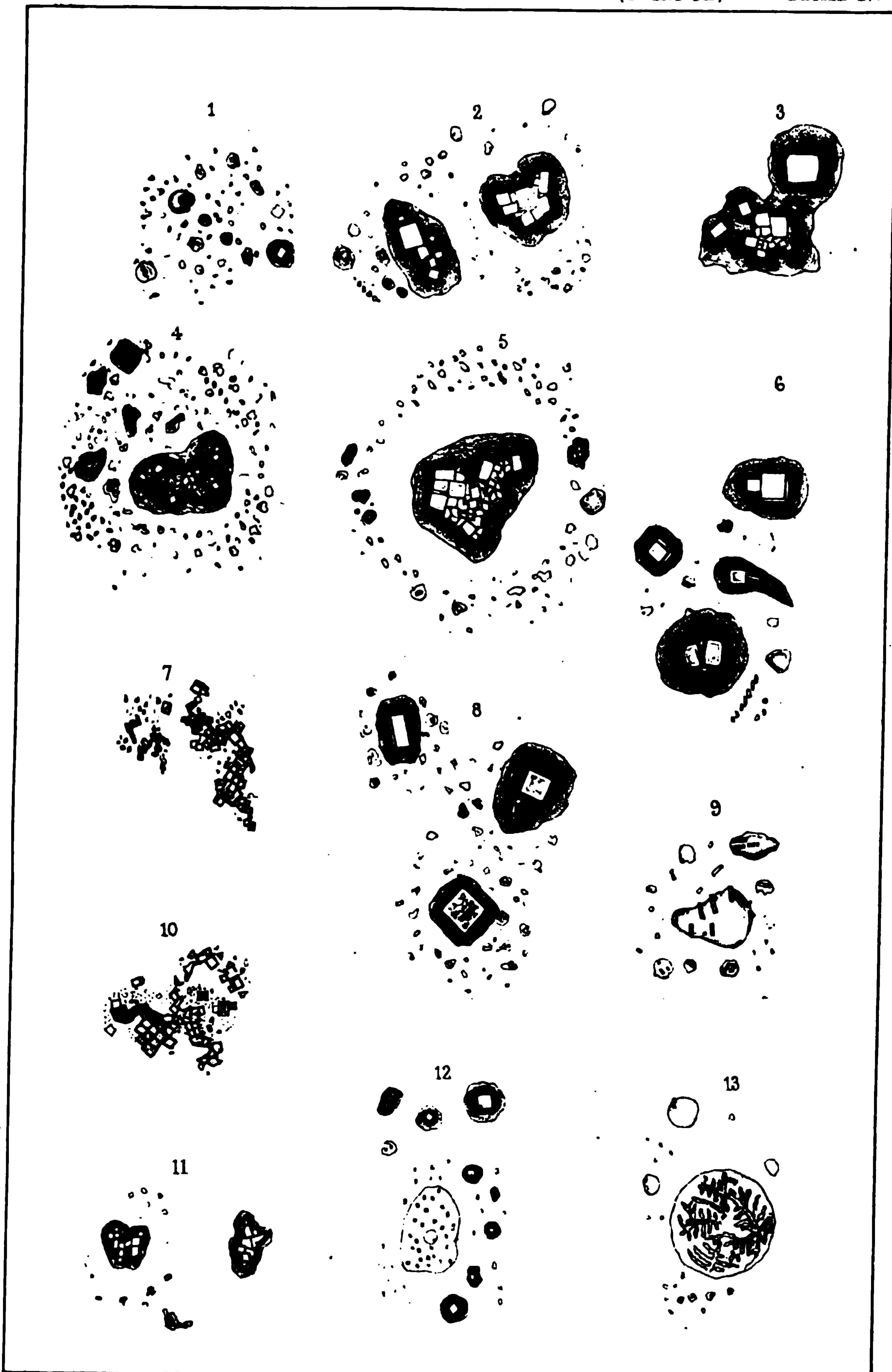


Fig. 2.



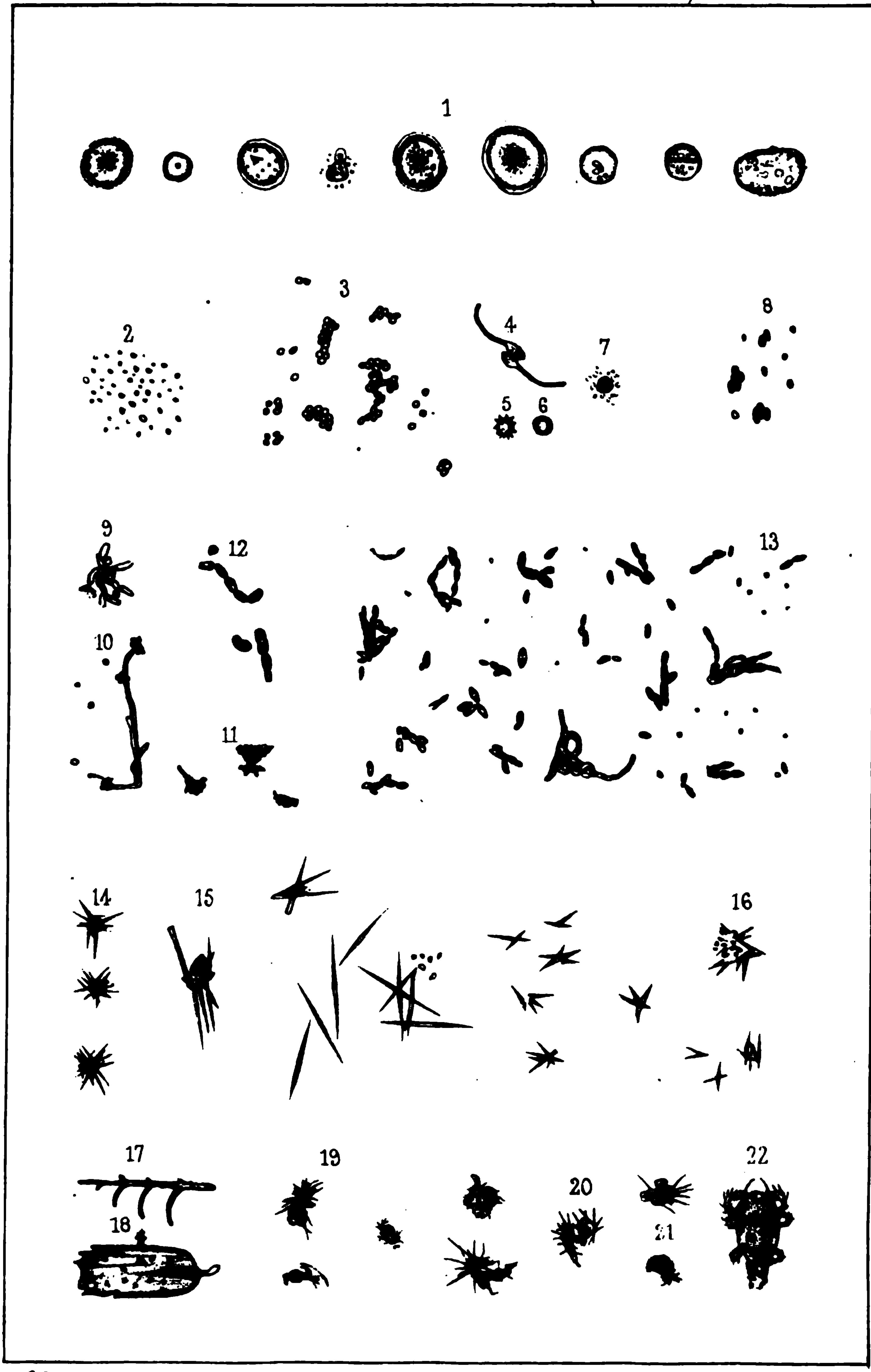
Dr. Barker on the Illumination of Microscopic Objects.

SEA BREEZE.



C. Sigerson, Del. P. W. Swan, Lith.

DR. SIGERSON on the Atmosphere

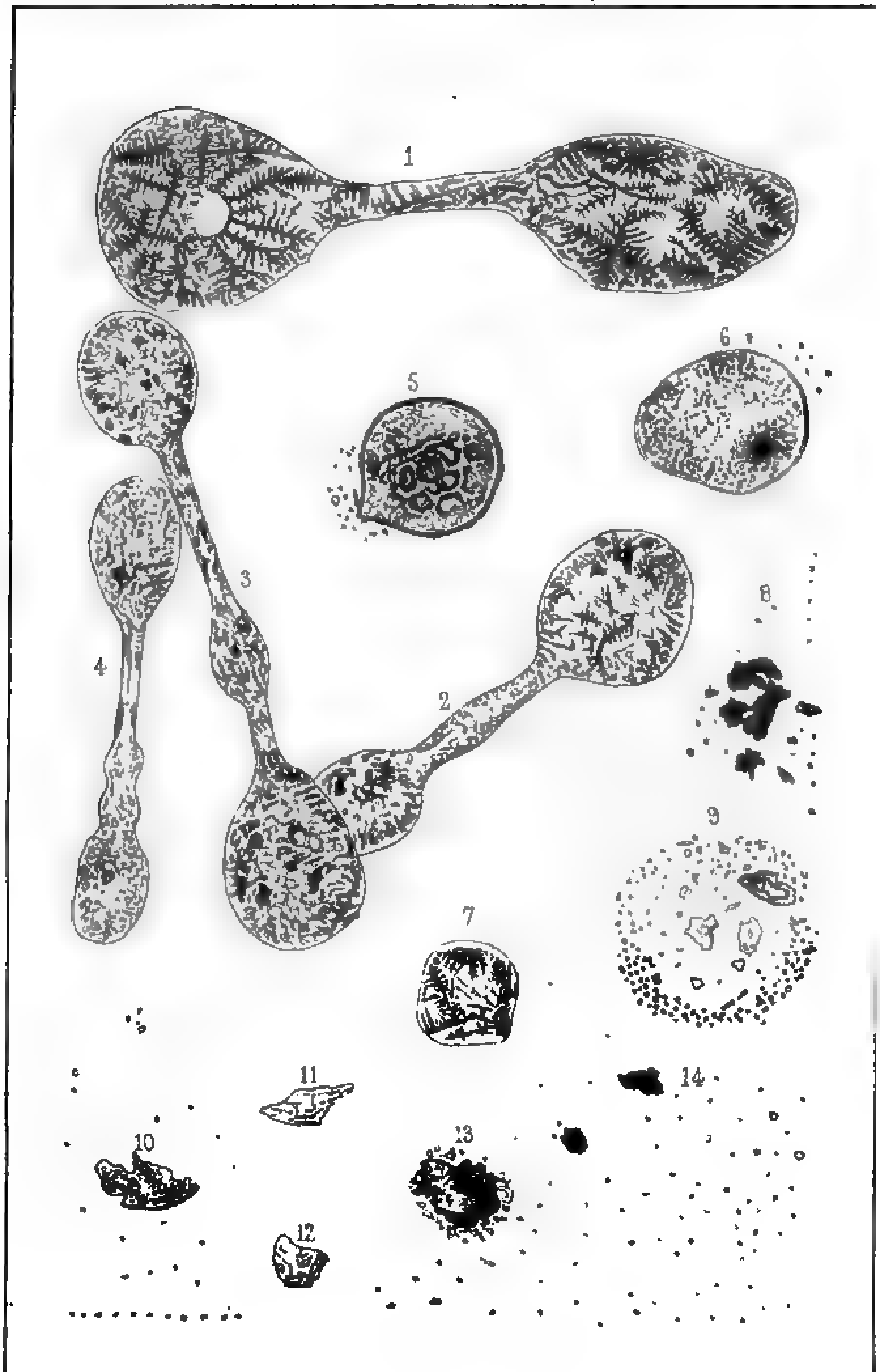


G. Sigerson, Del. P. W. Swan, Lith.

DR. SIGERSON on the Atmosphere.

CITY AIR

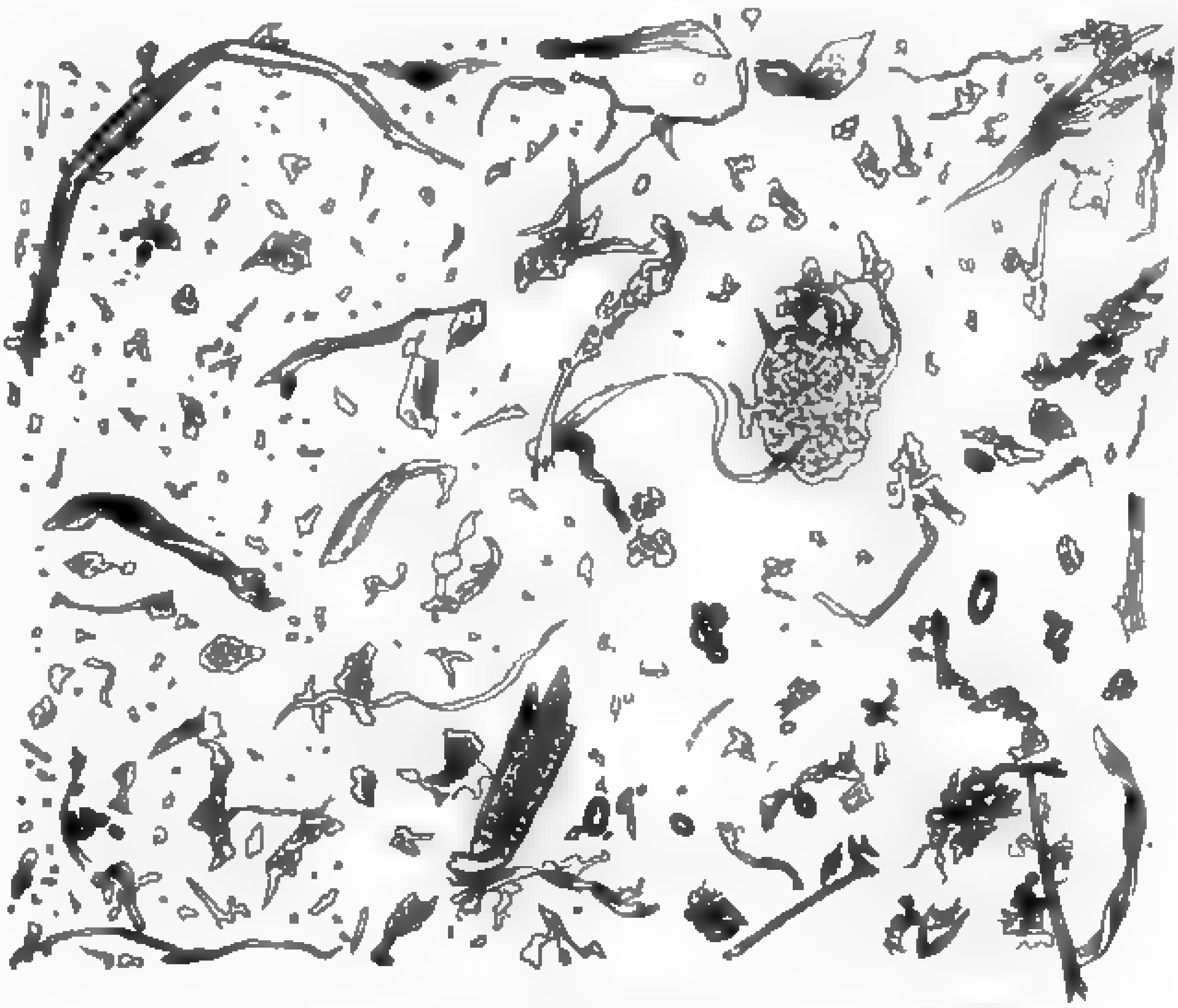
DR SIGERSON on the Atmosphere



G. Sigerson, Del. P. W. Jones, Lith.

DR. SIGERSON on the Atmosphere.

SHIRT FACTORY AIR

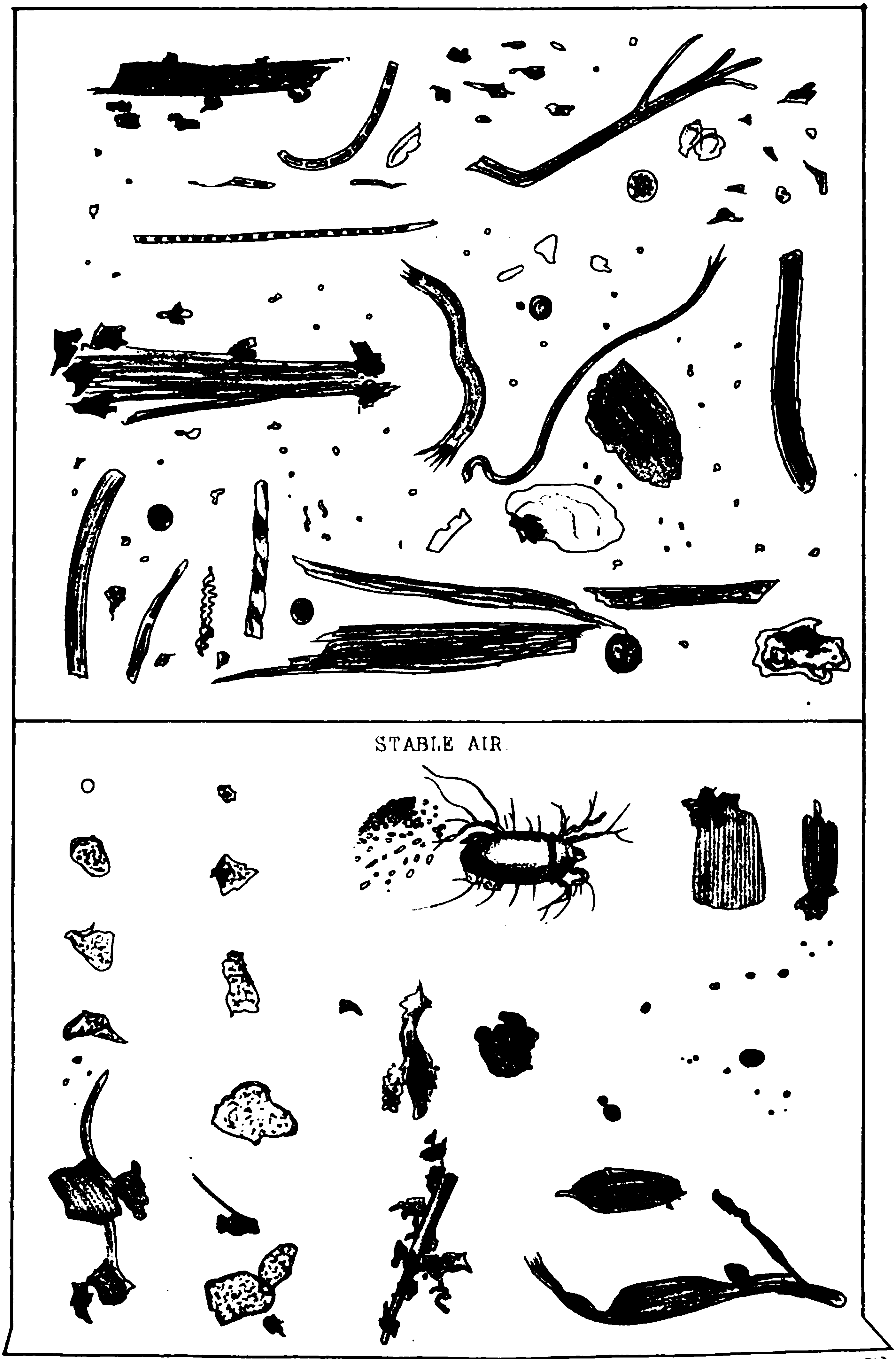


IRON FACTORY AIR

G. Sigerson del. F.W. Swan

DR. SIGERSON on the Atmosphere

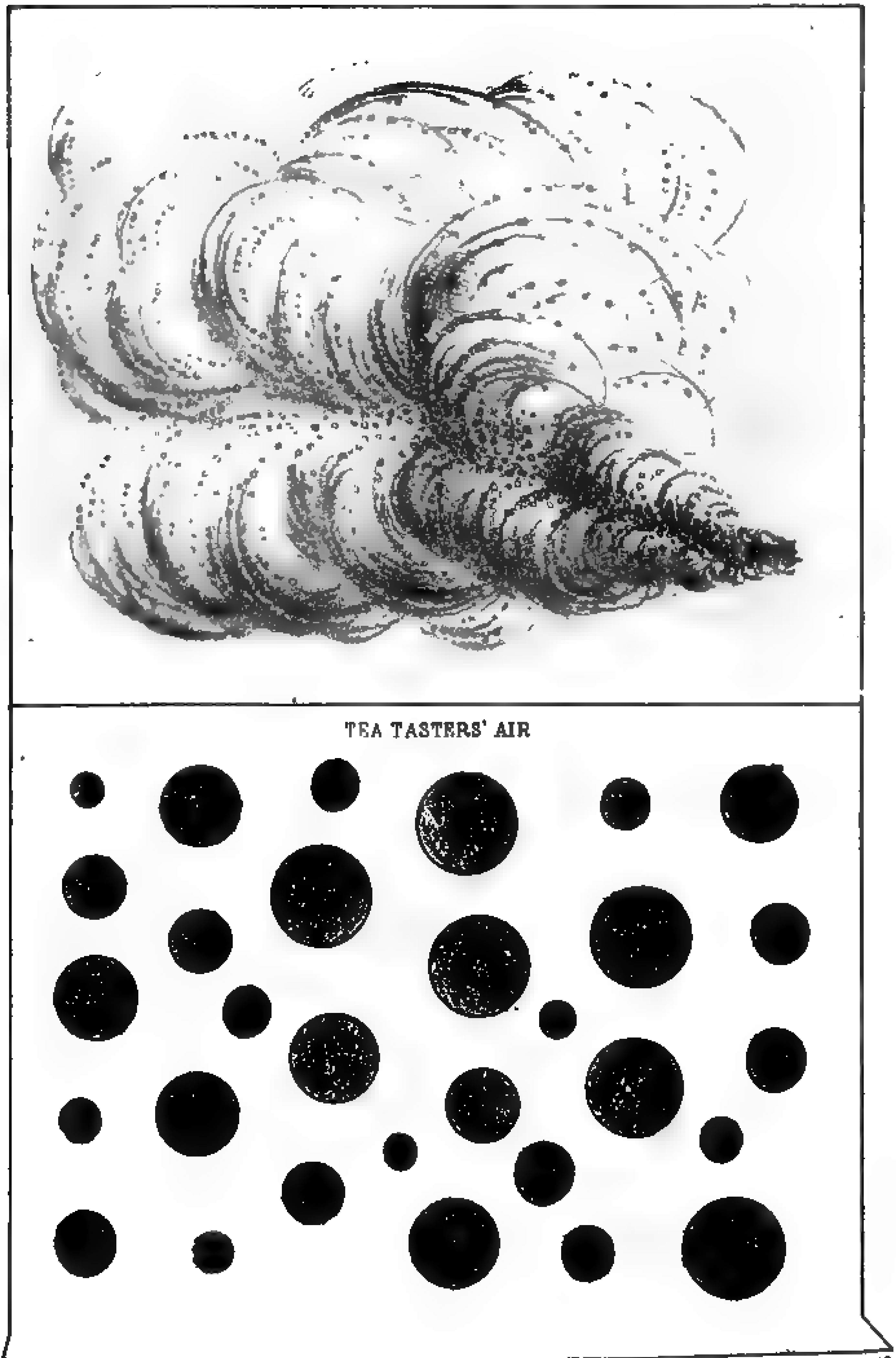
DISSECTING ROOM AIR



G. Sigerson, Del. P.W. Swan, Lith.

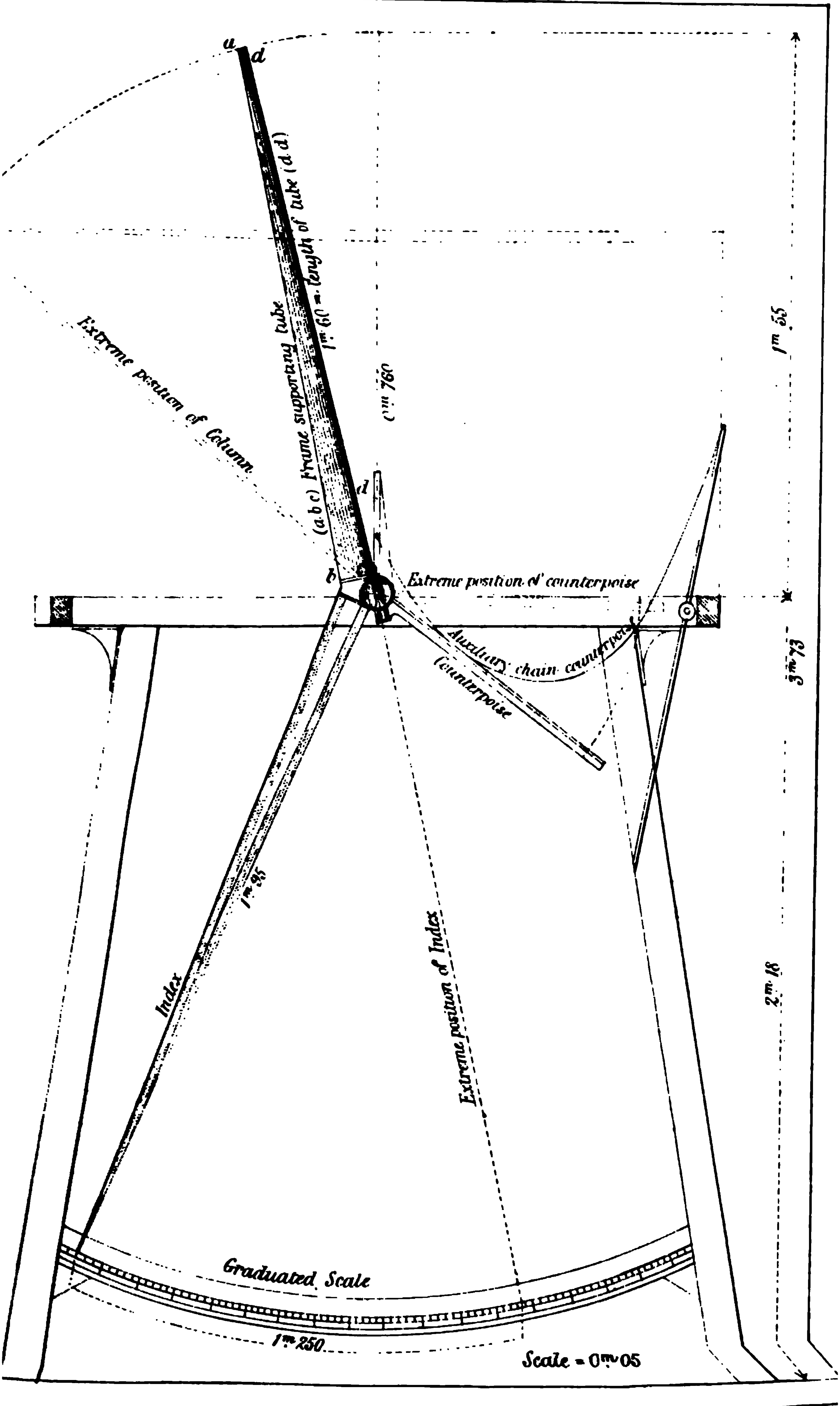
DR. SIGERSON on the Atmosphere

TOBACCO SMOKERS' AIR



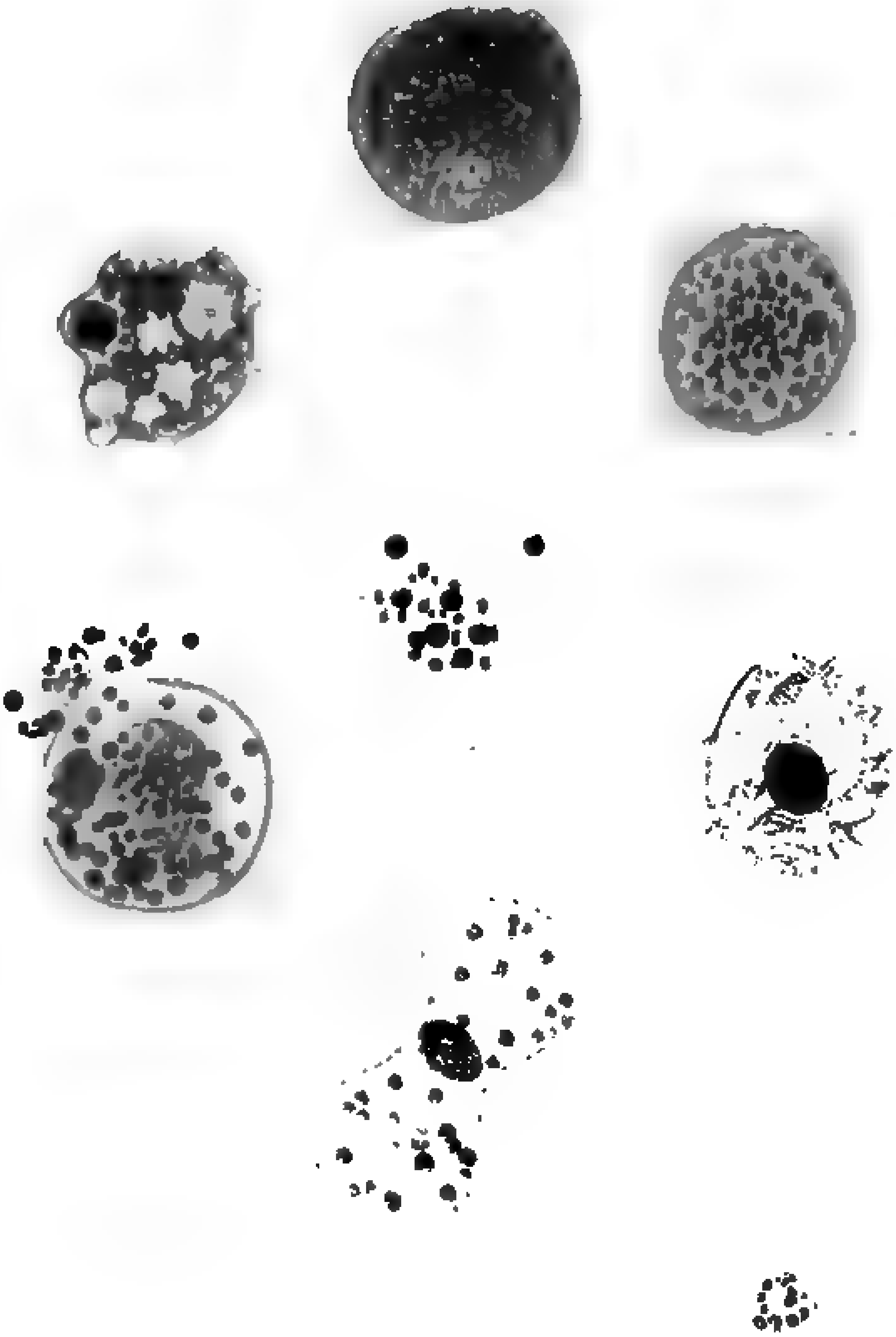
G. Sigerson, Del.

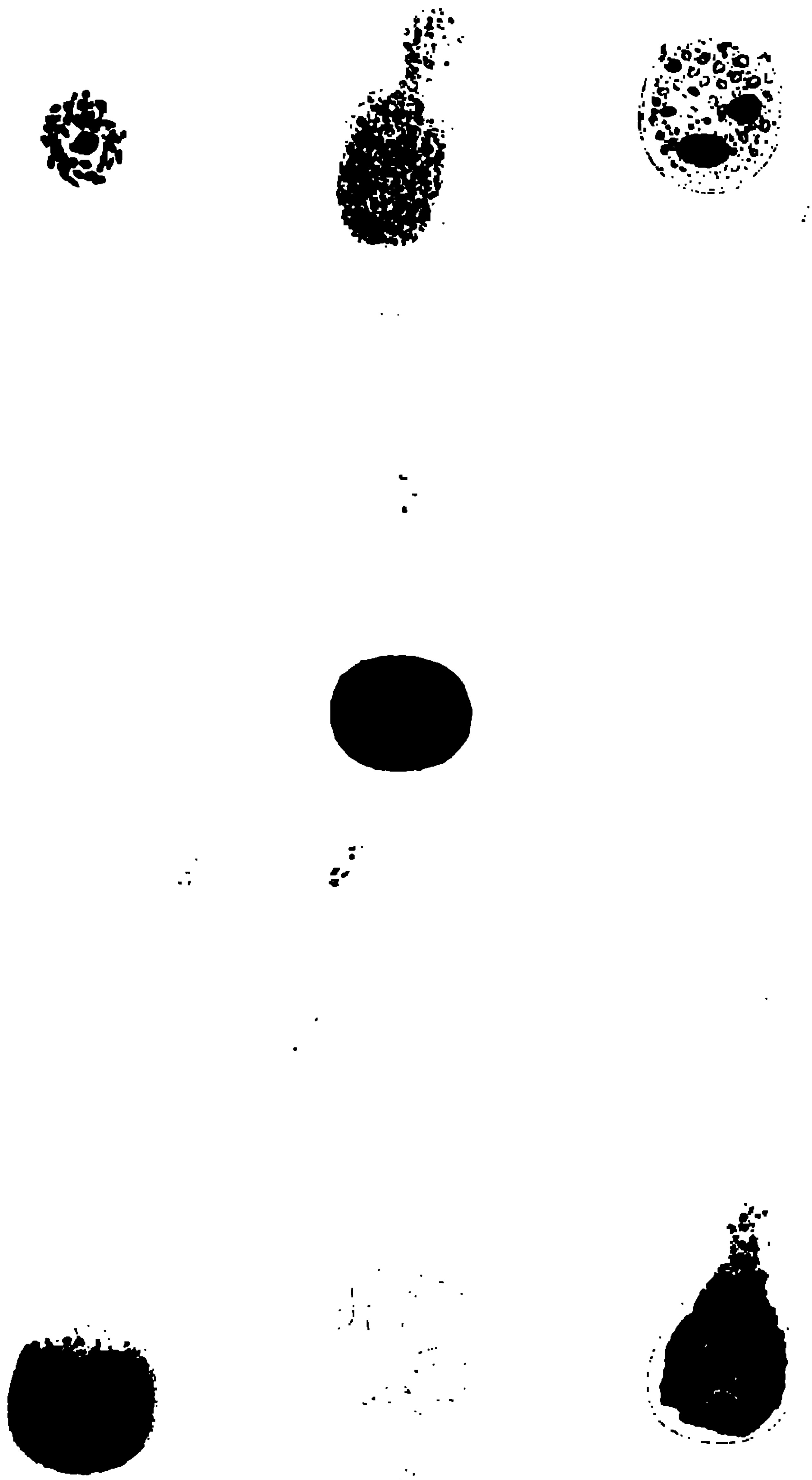
DR. SIGERSON on the Atmosphere

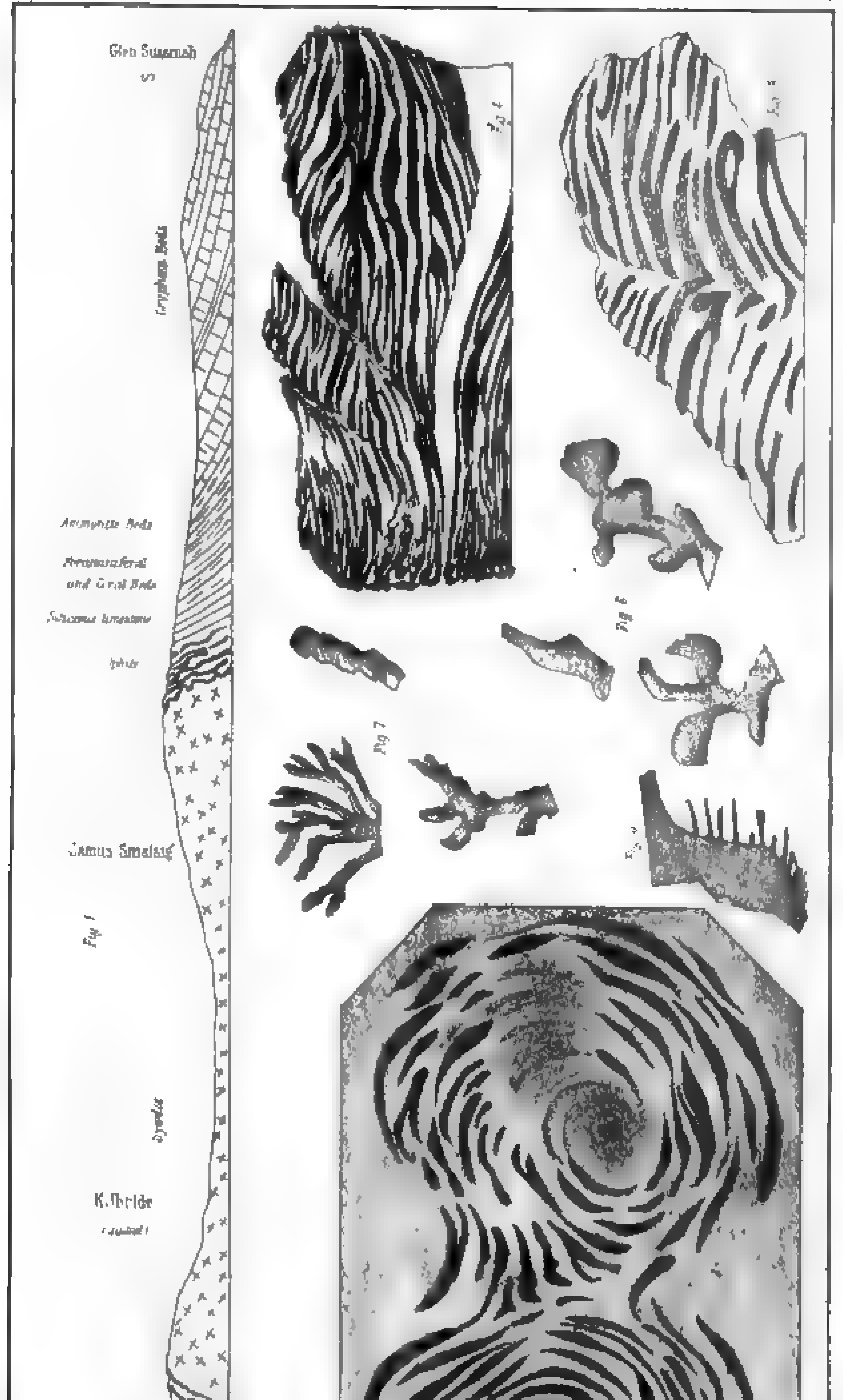


P W Swan, Lith

PROF. O'REILLY on proposed new arrangement of Barometer

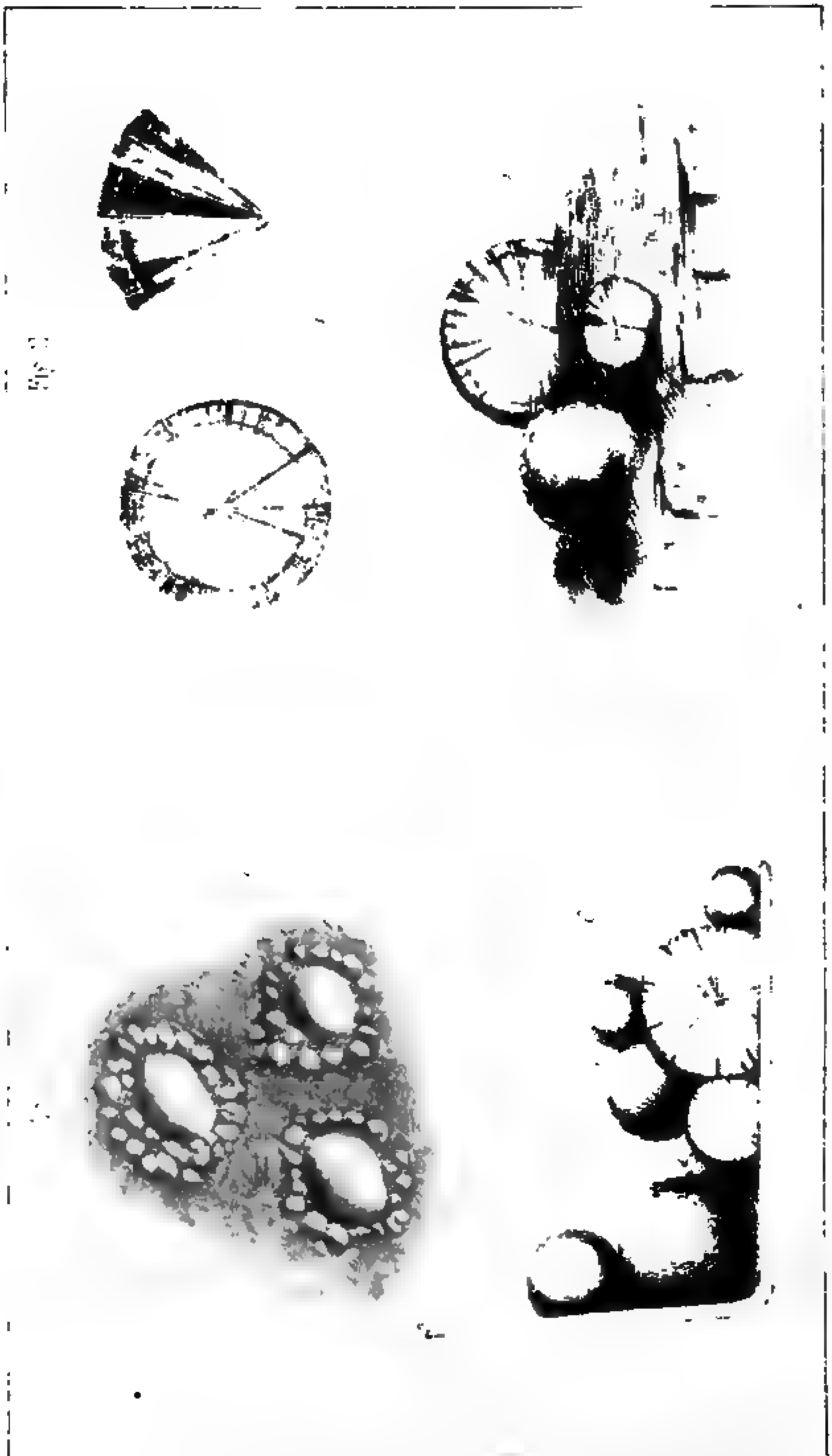


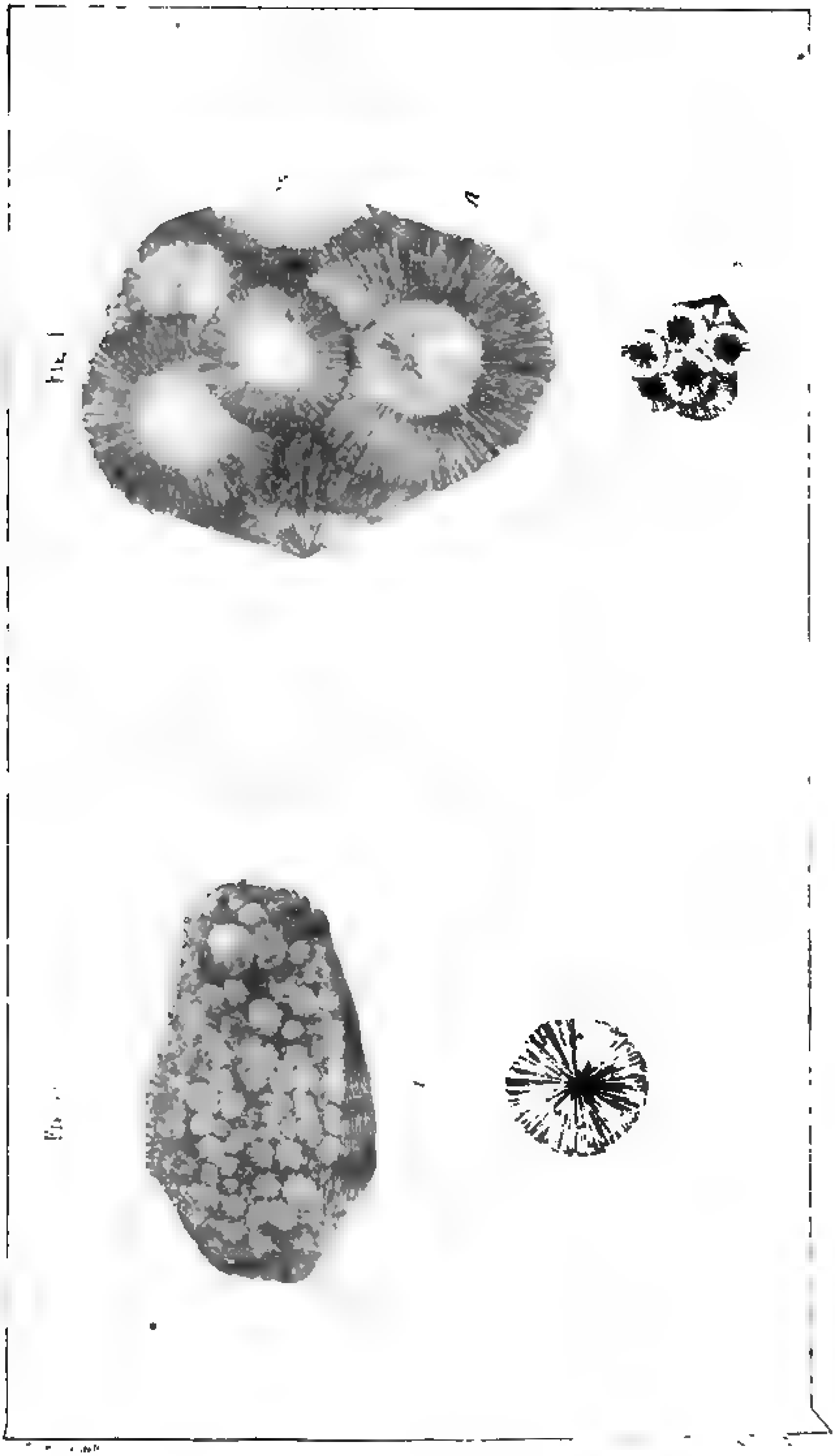




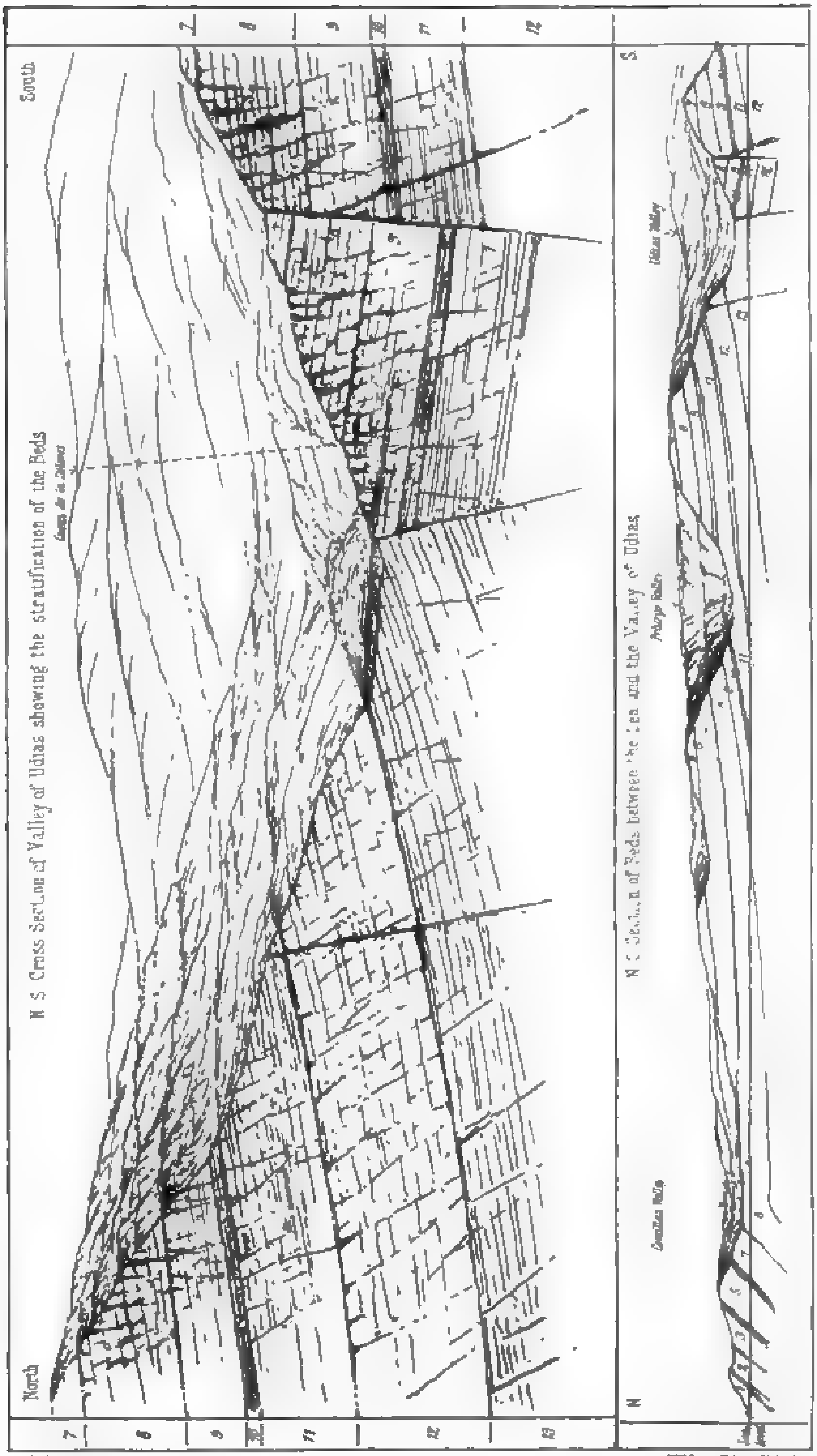
P. W. Swan, Lith. Forster & Co. Dublin.

PROFESSORS KING and ROWNEY on the Ophite of Skye



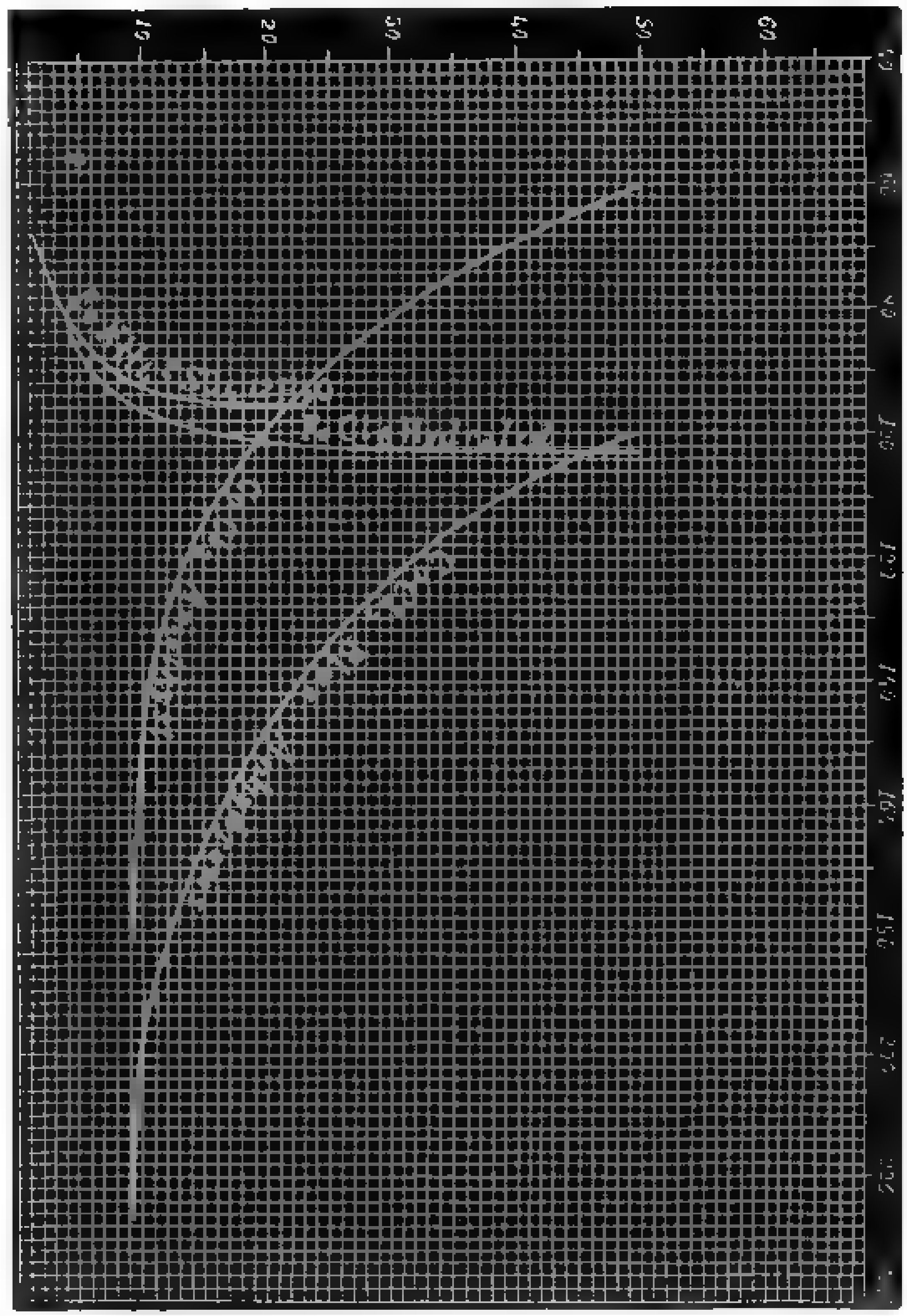


DOCTOR SIGERSON on Botany



J P O'Reilly Del

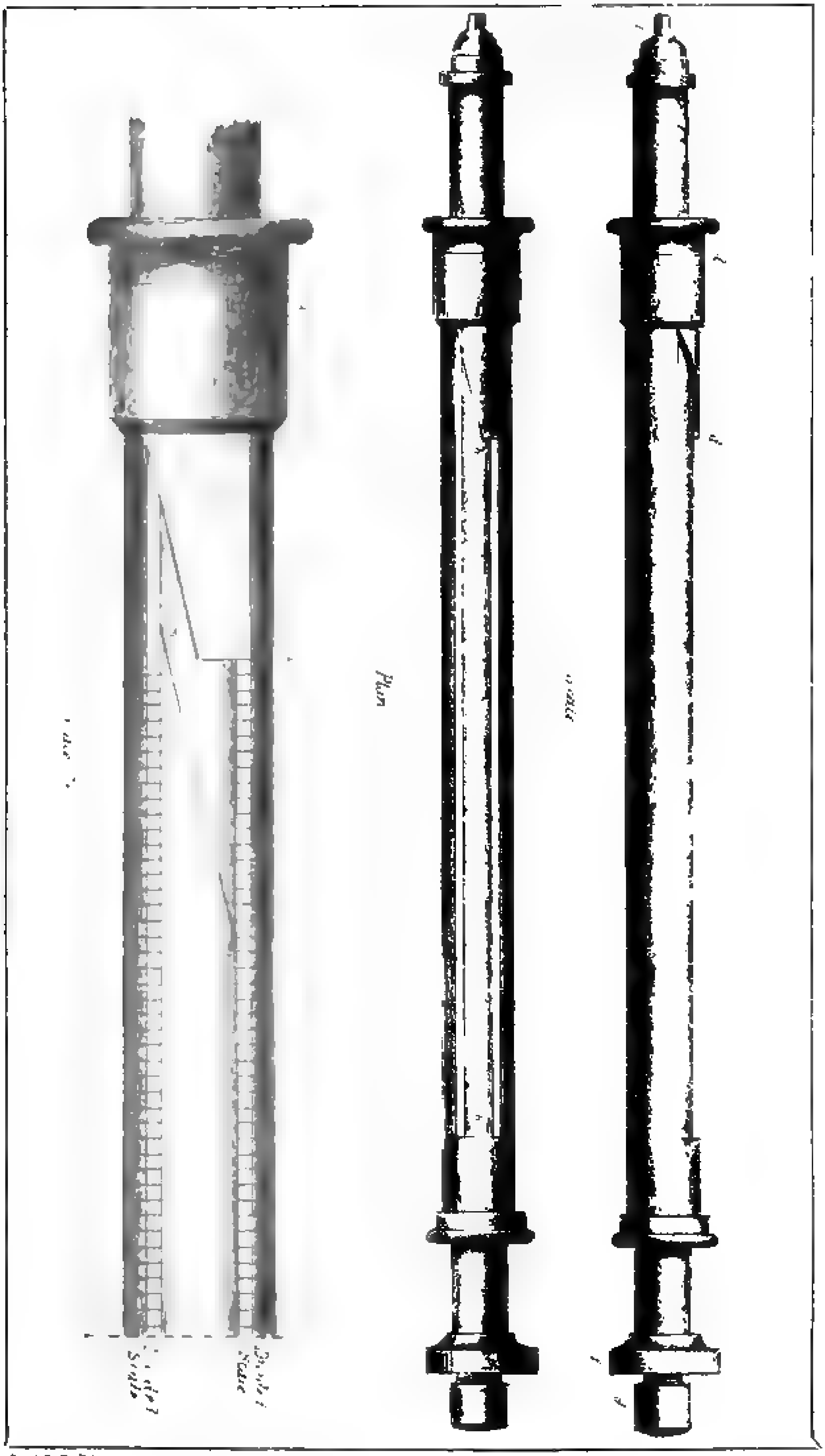
PROFESSORS SULLIVAN & O'REILLY on the Tithonic Stage in the Province of Santander (Spain)



Curves illustrating the distinction between dissociation attended with basic decomposition, and the dissociation of water of hydration.

Braithwaite del. D. Blair, lith.

Dr MOORE ON IRISH BRYOLOGY.



Prof O'Reilly Del.

PROF O REILLY On a new form of Galvanometer

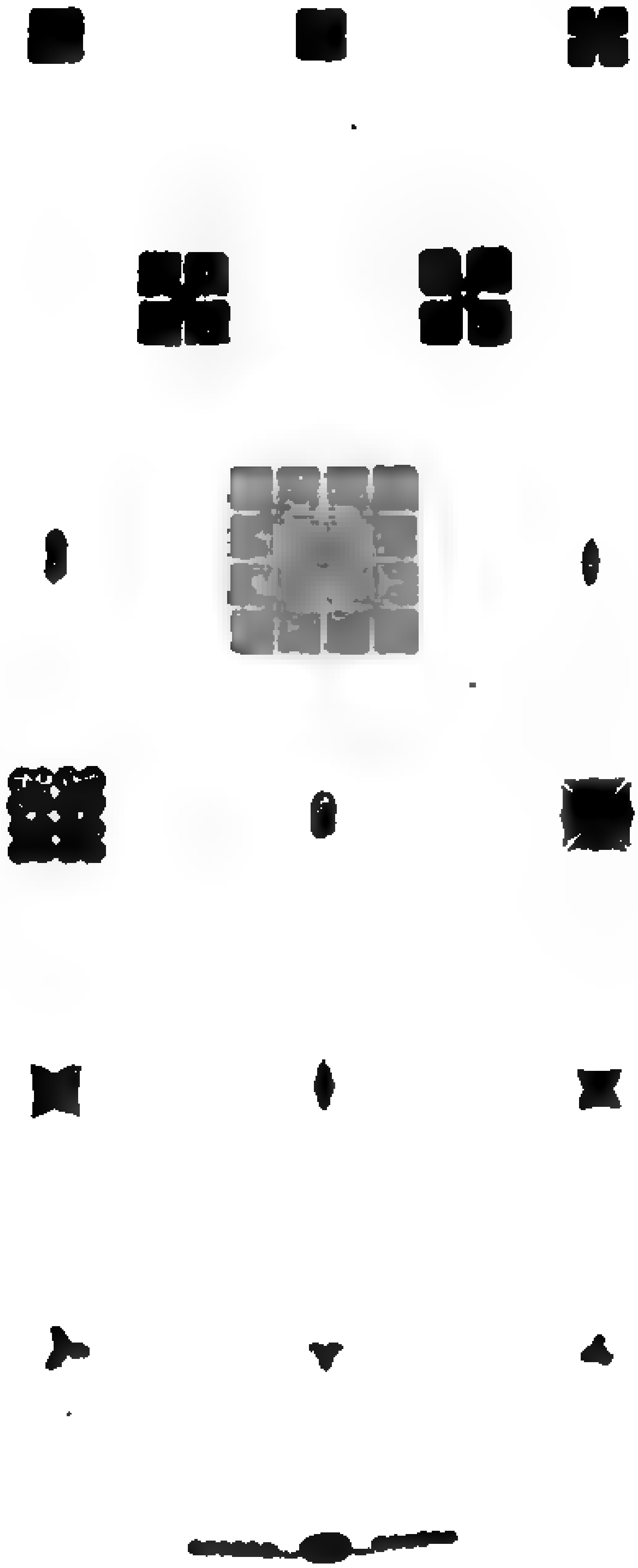


Fig. 2.

DR. BALL—ON THE ORBIT OF THE BINARY STAR ξ URSAE MAJORIS.

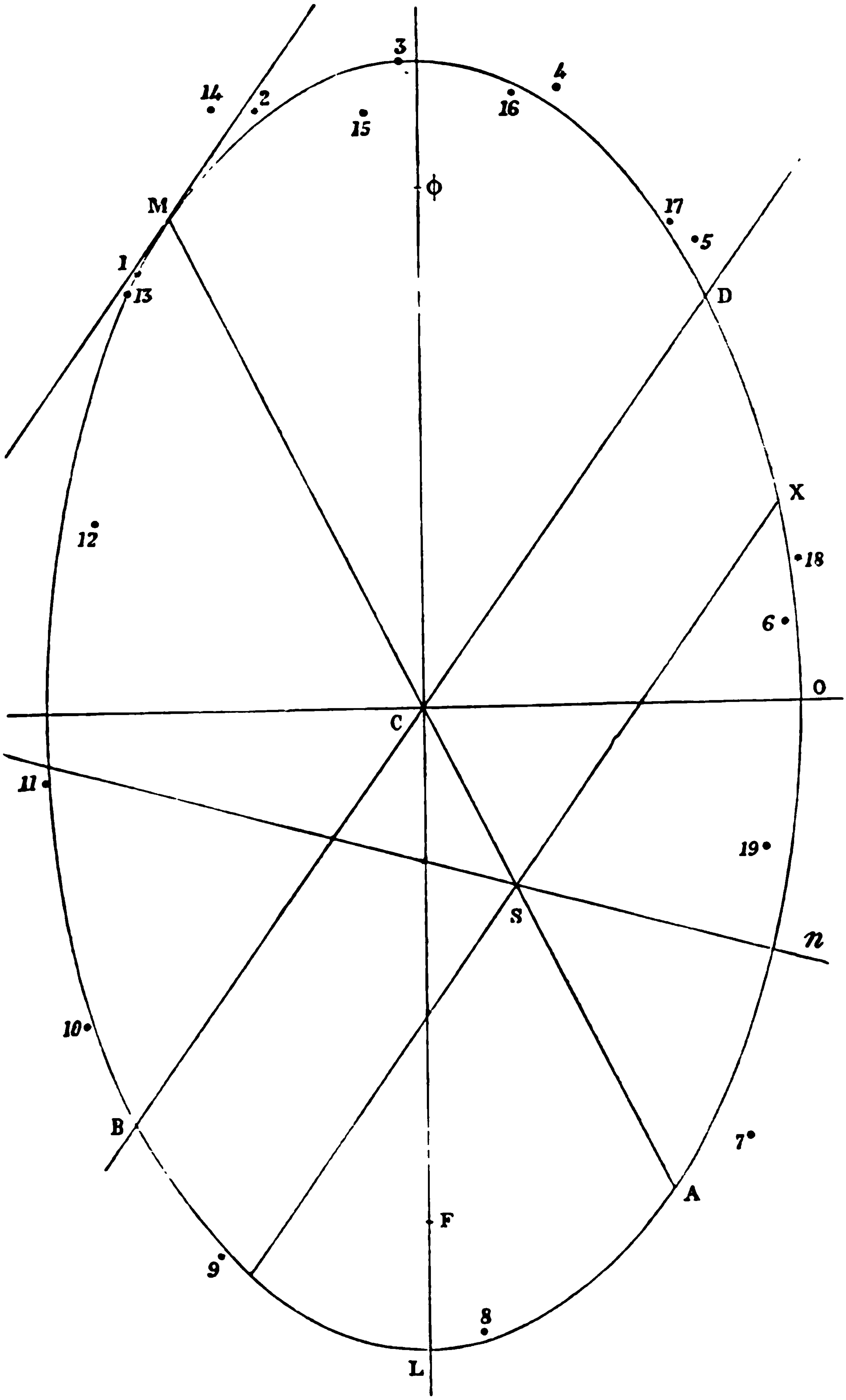
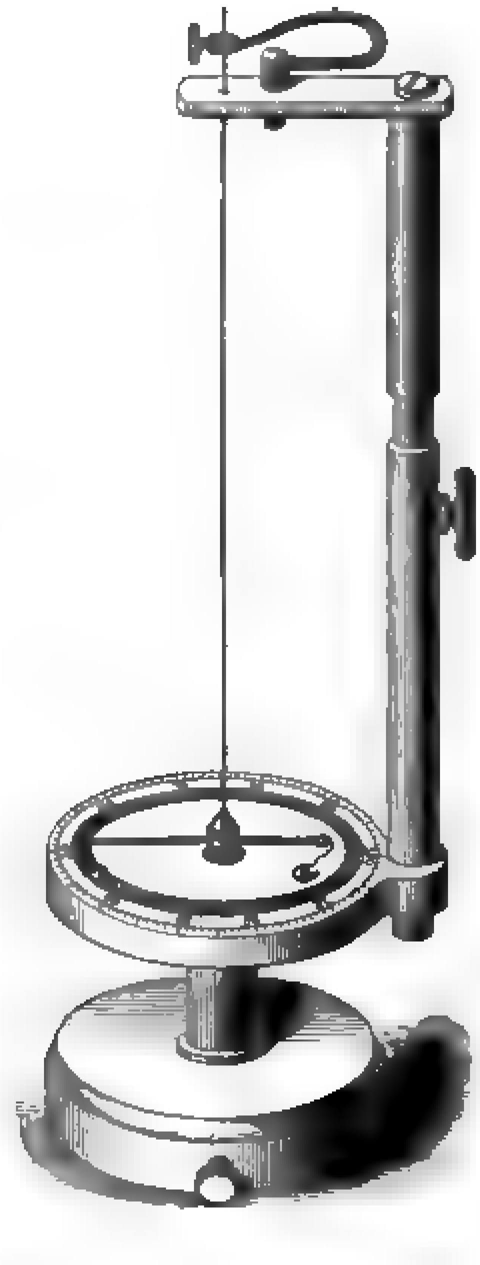


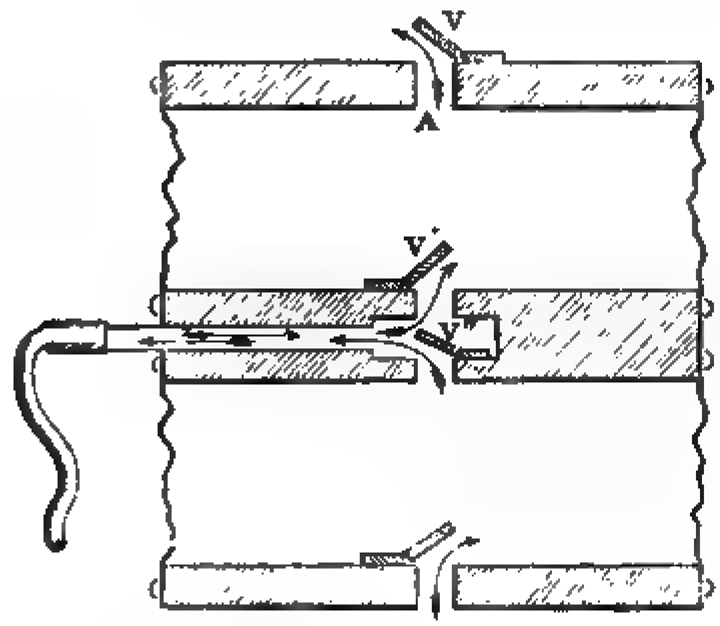
Fig. 2.

DR. BALL—ON THE ORBIT OF THE BINARY STAR ξ URSAE MAJORIS.



MR. O'DONOVAN—SELF-REGISTERING COMPARABLE HYGROMETER.

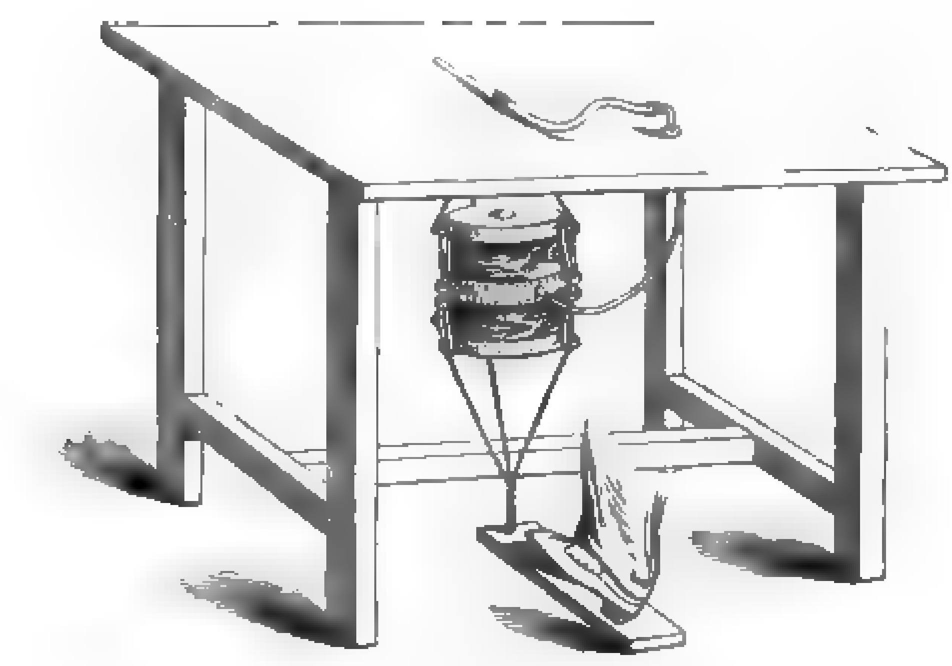
Fig. 1



Section of Apparatus, showing Valves.

For large animals it might be necessary either to have the aperture at A smaller than any other of the valvular apertures, or else to have the valve V surrounded by a graduated spring, so as to obviate the tendency of the air to pass directly from V'' to V'. With small animals, as rabbits, I have found the pressure of the air in the upper chamber quite sufficient.—N. F.

Fig. 2



Apparatus Mounted, showing Elastic Bands and Treadle.

Fig. 3.

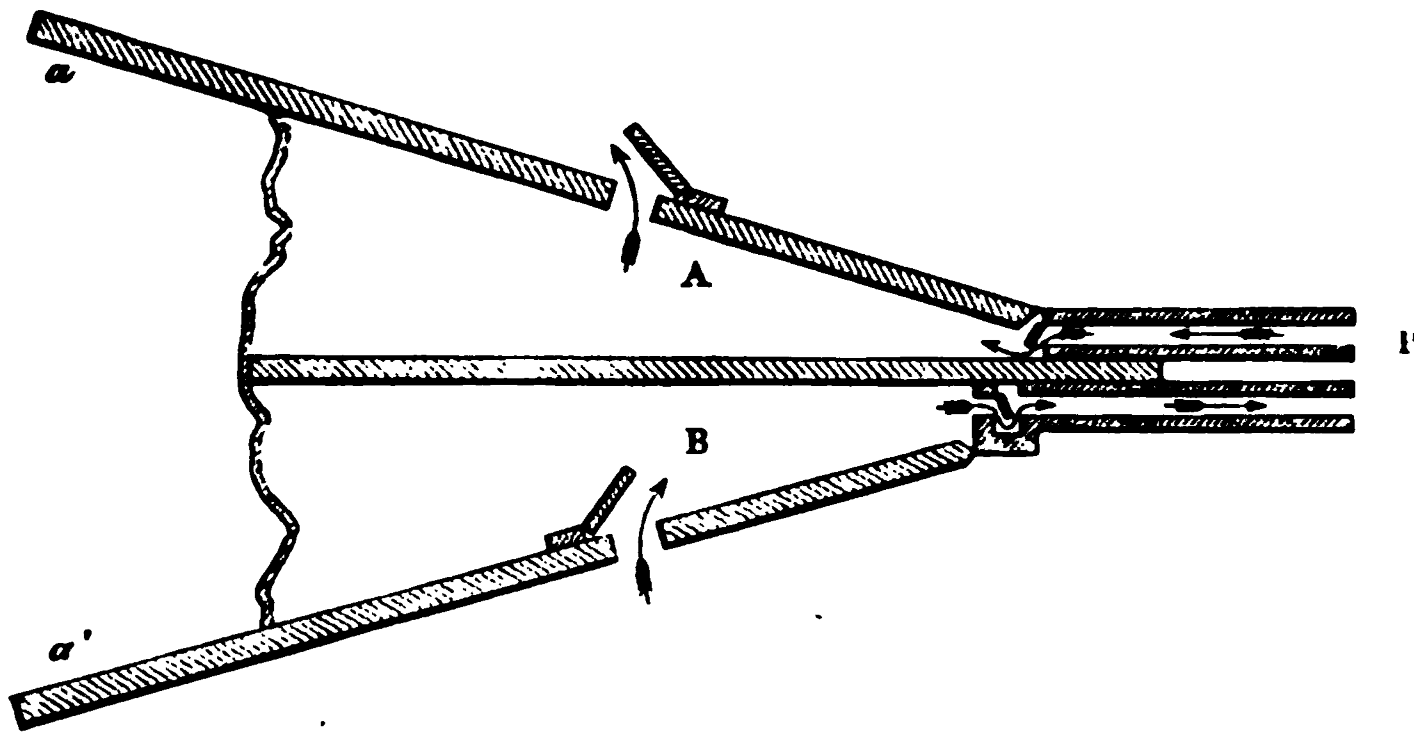


Fig. 4.

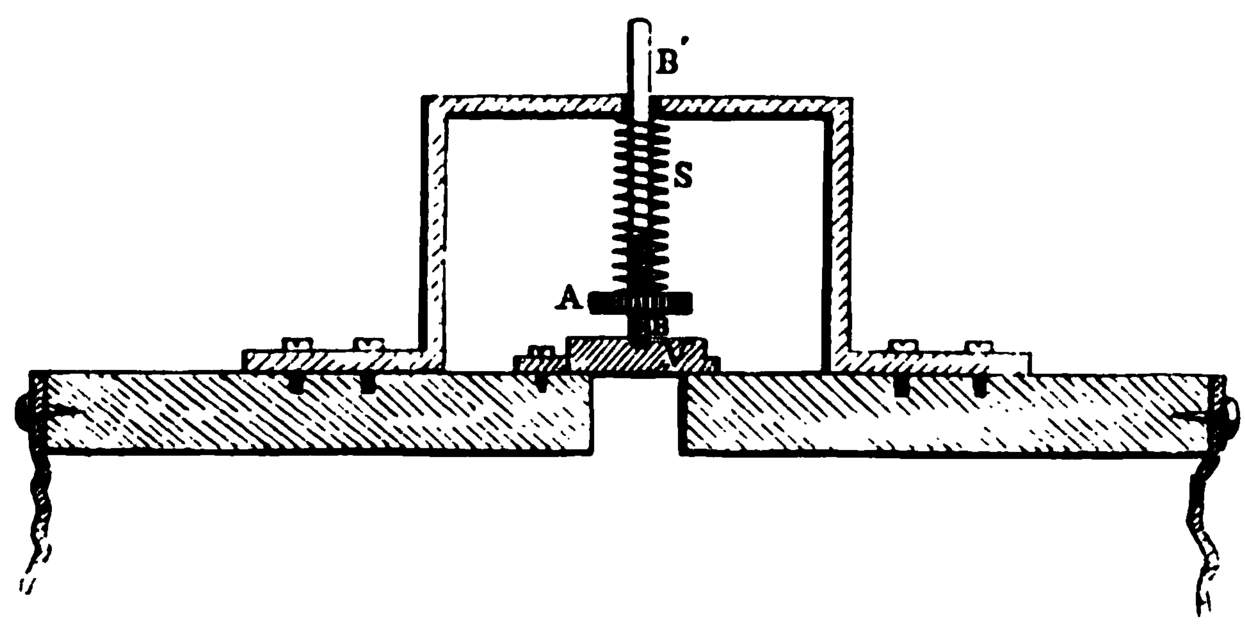


Fig. 4.—A, a button regulating the tension of the spring S on the valve V, by screwing up or down on the rod B B′ attached to the valve V.

Fig. 5.

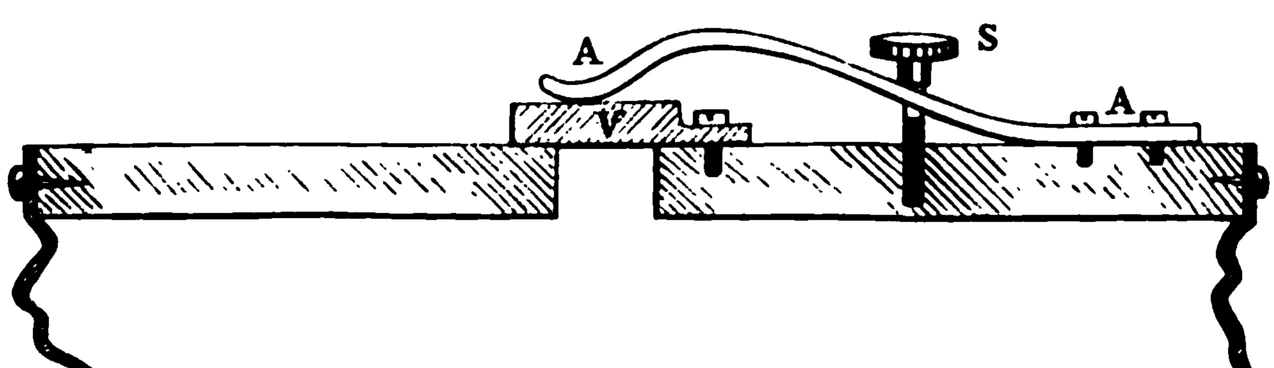


Fig. 5.—S, a thumb-screw, to regulate pressure of spring A A on the valve V.

Fig. 1.

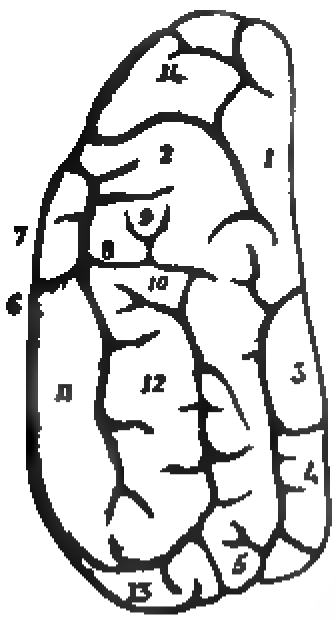


Fig. 2.

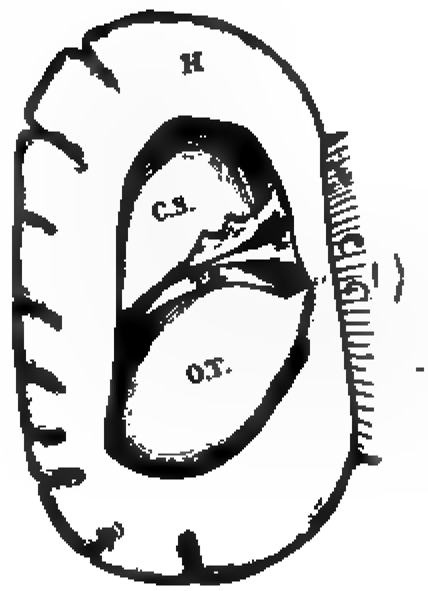
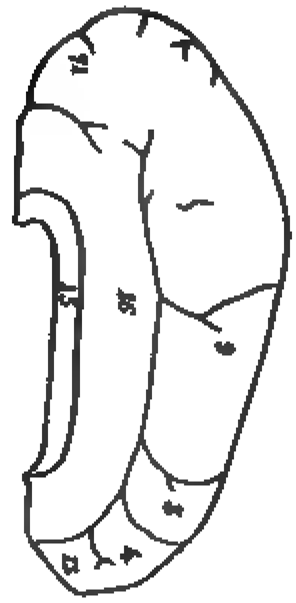


Fig. 3.



Cerebrum of Chæropsis Liberiensis.

Fig. 4.

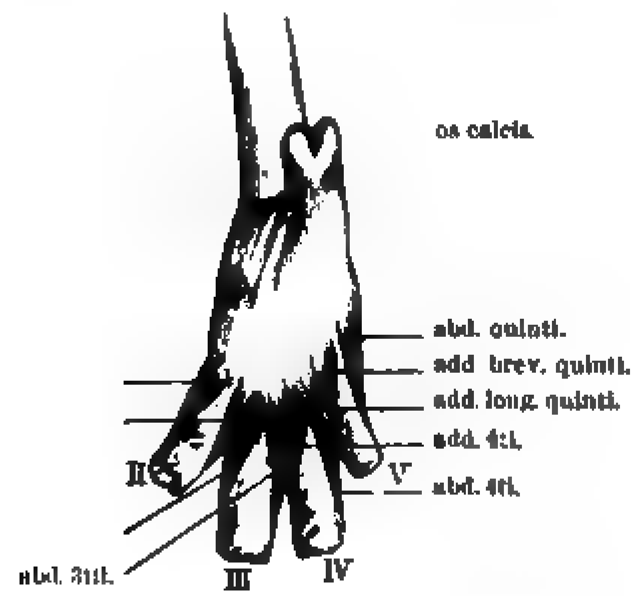
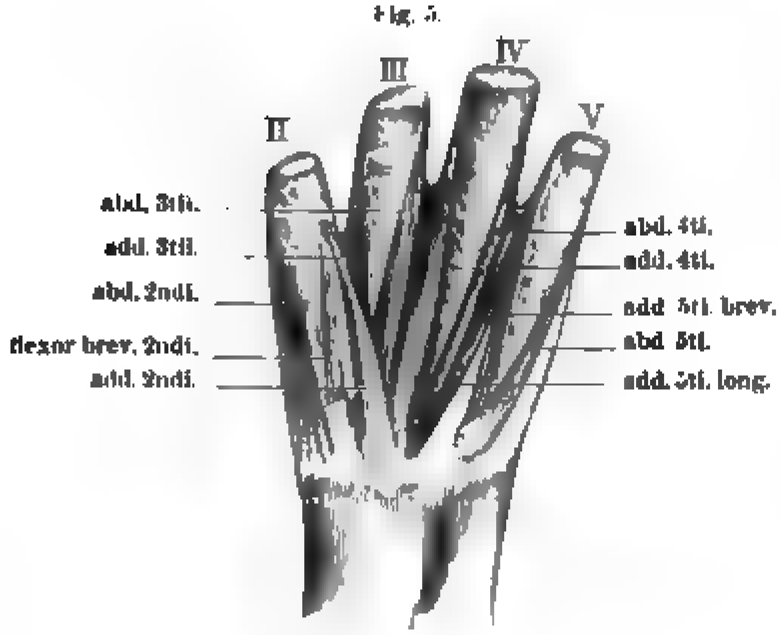


Fig. 5.



Manus and Pes of Chæropsis Liberiensis.

Fig. 2.

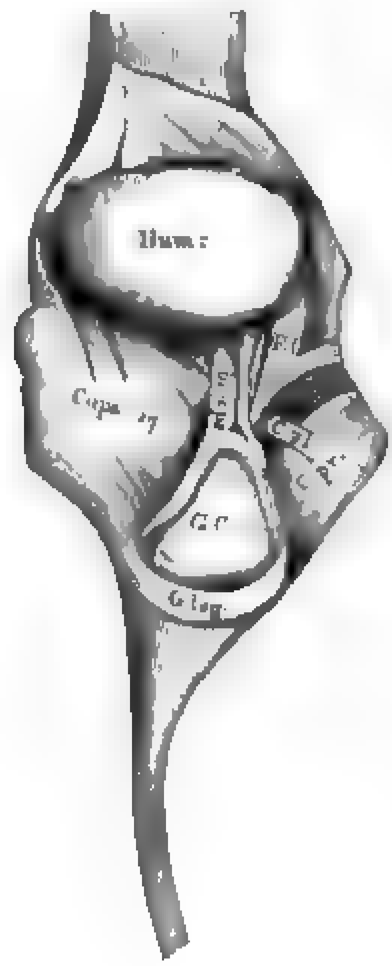


Fig. 1

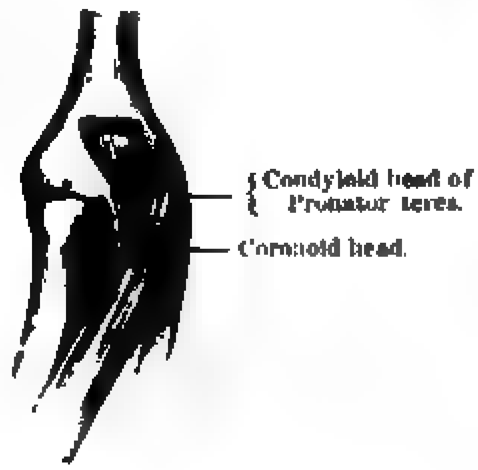
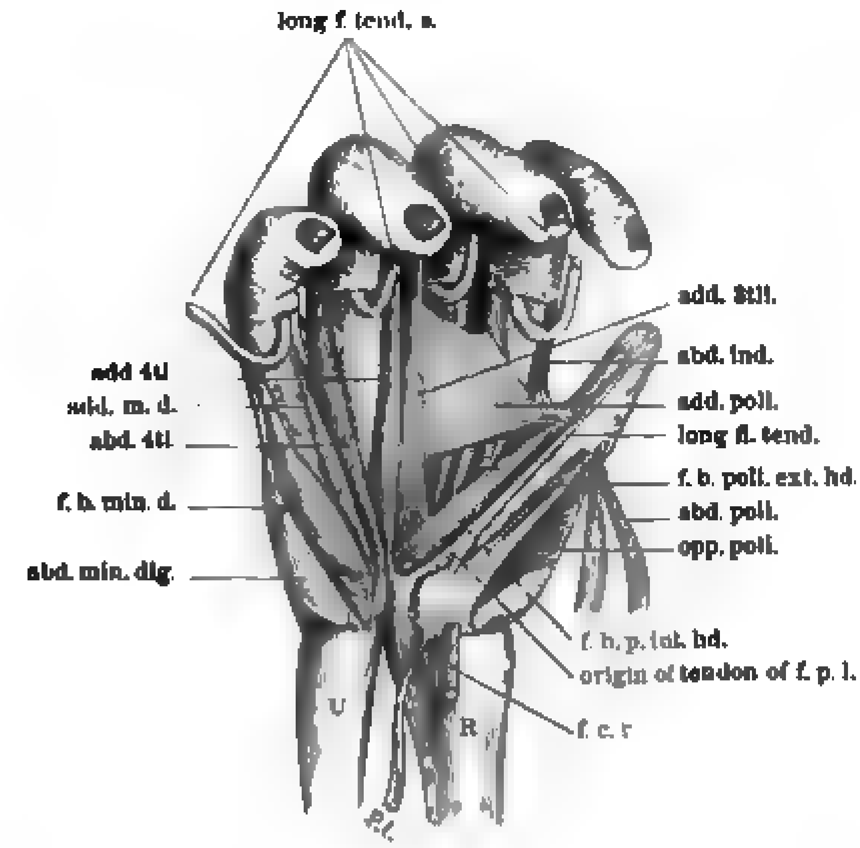
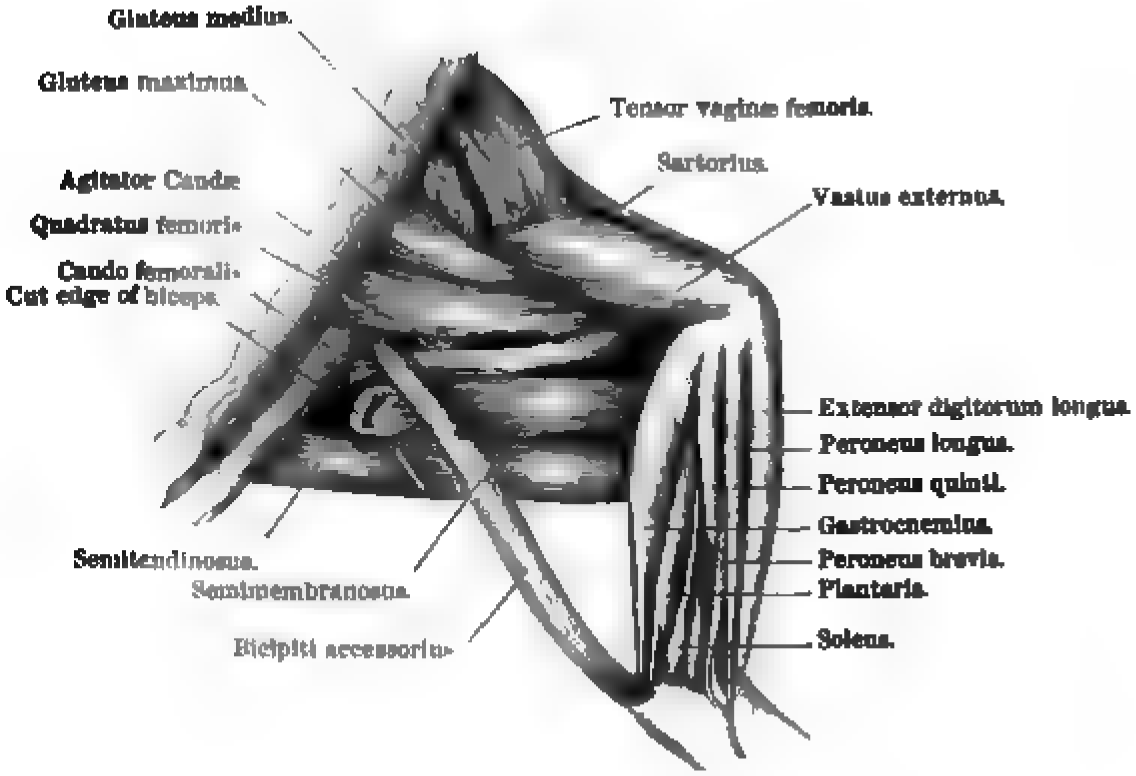


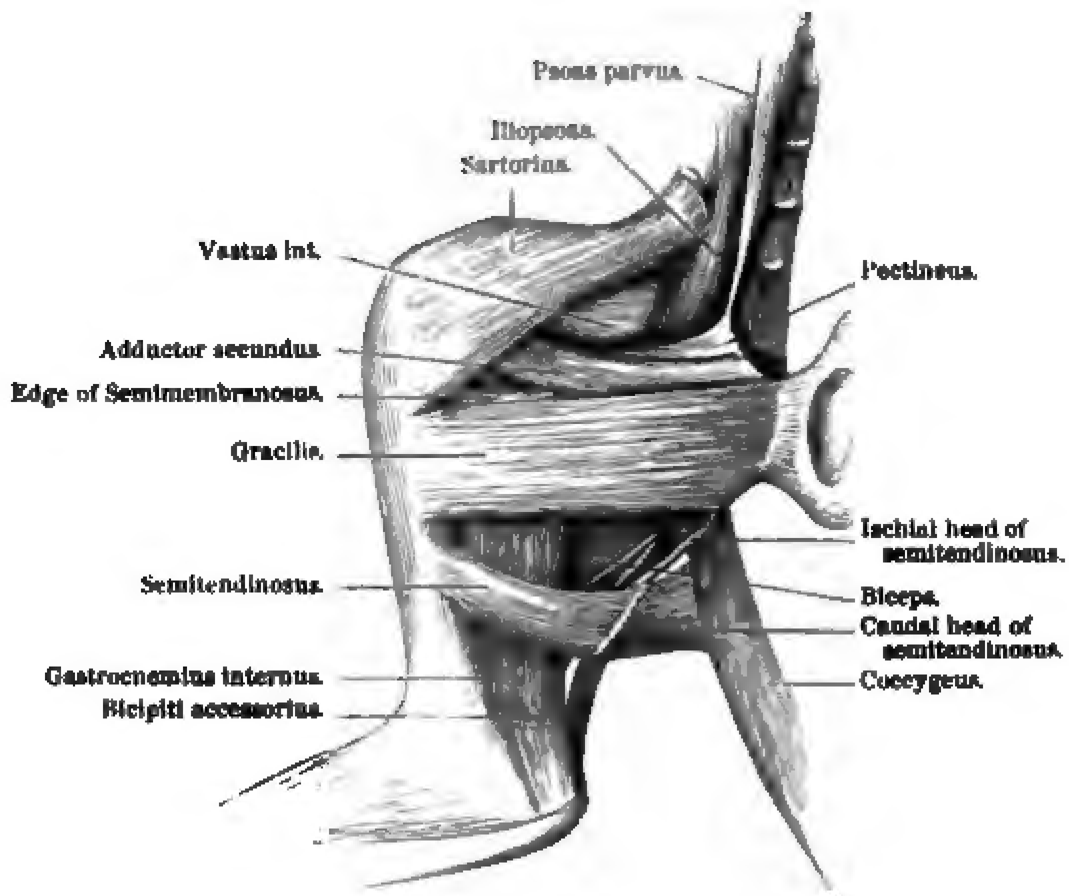
Fig. 3.



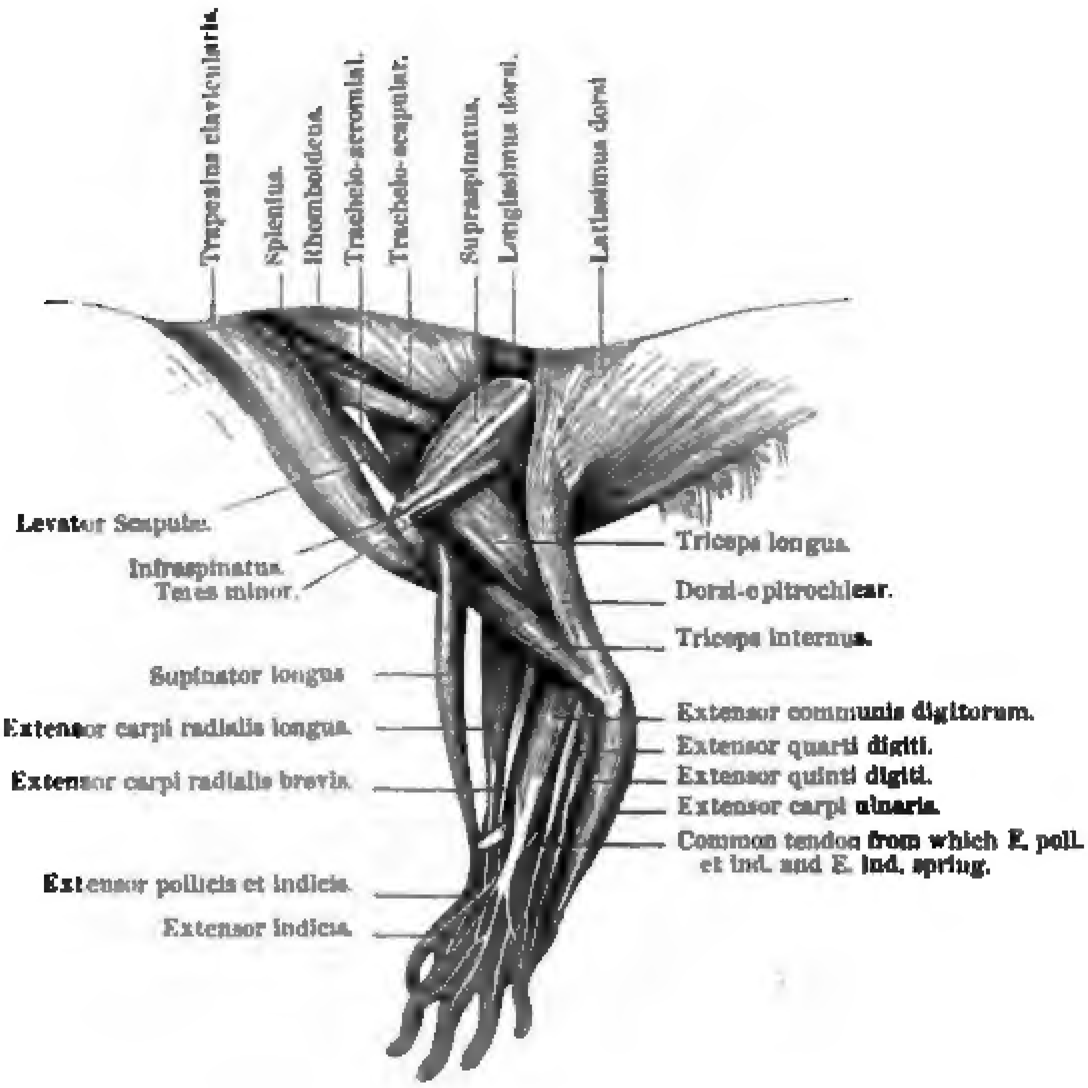
MANUS OF GORILLA.



DR. MACALISTER—AONYX LEPTONYX, RIGHT LEG.



DR. MACALISTER—AONYX LEPTONYX, RIGHT LEG.



DR. MACALISTER—AONYX LEPTONYX, LEFT ARM.